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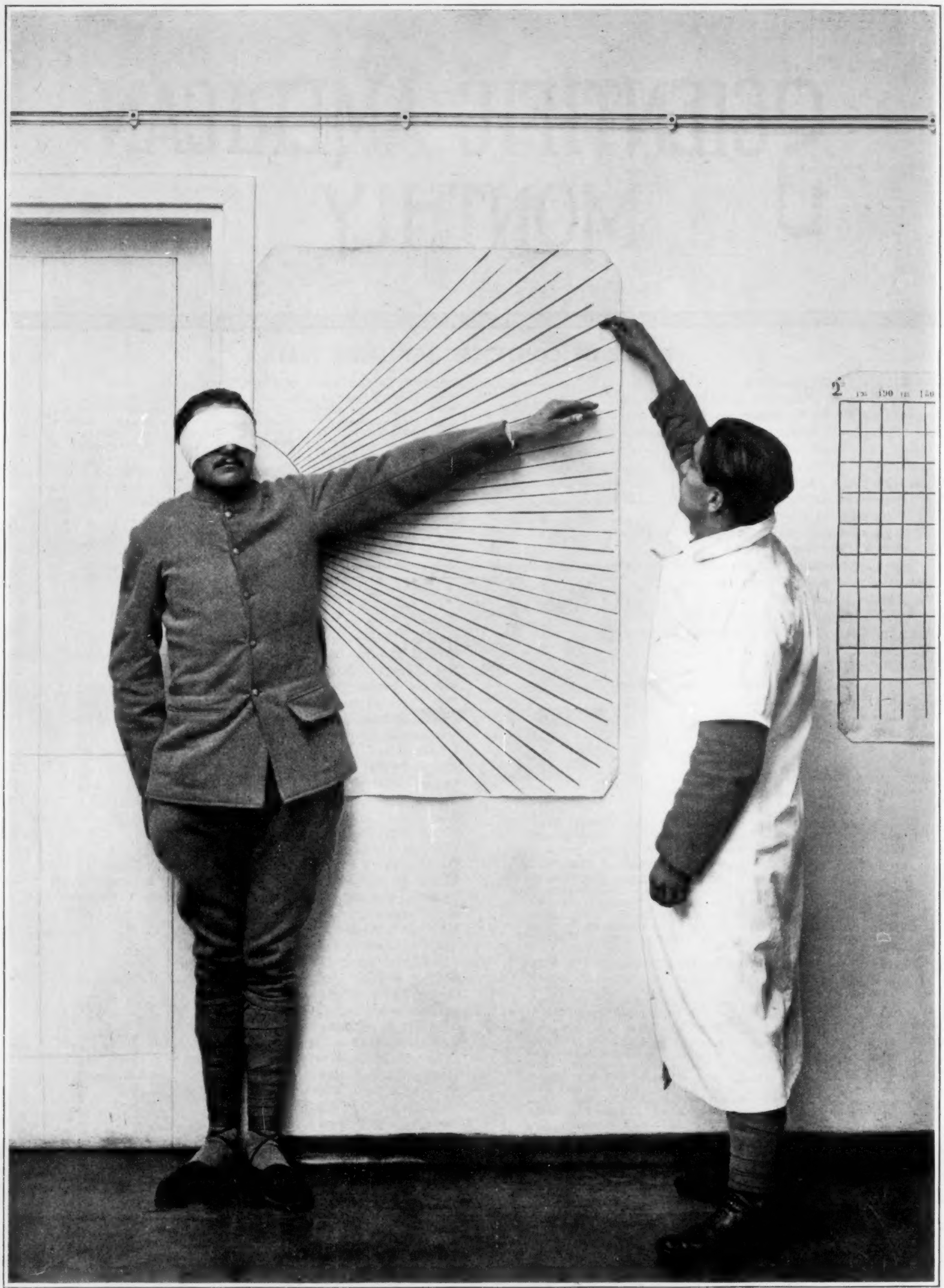

THE CULT OF THE SOUND BODY—DR. BOIGEY'S SYSTEM OF STUDYING THE MUSCULAR SENSE BY THE IDEA OF POSITION
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HALF A MILLION HORSEPOWER FROM THE TIDES

WE have been wont to look upon solar heat as the original source of all available power on earth. Fuels are unquestionably stored solar heat energy, while water power and wind power also have their origin in the same source. Wave power is really disguised wind power and that, too, is attributable to the heat which the sun pours upon this planet.

There is another form of power, however, of which the sun contributes only a minor part: the chief contributor being the moon. Tidal power is in a very different class from all other powers in the fact that heat plays no part in its generation. Such use as has been made of the power of the tides is so insignificant as to be hardly worth recording.

Tidal power is so widely diffused that in most localities it is hardly worth utilizing; or else it calls for engineering construction of a discouragingly vast extent. One of the most serious draw-backs to the development of tidal power lies in the fact that the ebb and flow follows a lunar schedule while the inhabitants of this planet regulate their habits by the apparent diurnal revolution of the sun. Our power plants have to carry a heavy load in the day time to furnish power for industrial purposes and there is another heavy peak load in the evening when the public uses artificial light to prolong the day. Unfortunately a tidal power plant cannot adapt itself to existing requirements, but must operate under a hydraulic head that is ever varying rhythmically between zero and maximum. Being regulated by the moon instead of the sun this peak of power output is just as likely to come at a moment when we sun-regulated humans least need it, and, on the other hand, when our demands for power reach a maximum the tidal plant may not be turning a wheel. Obviously, to be at all successful, the plant must be provided with means whereby surplus energy, developed at ebb-tide may be stored temporarily and delivered later, thereby giving a constant output regulated in accordance with the demand. The most practical and economical storing system consists in pumping water into a reservoir from which the water may be fed back, as required, to drive an auxiliary plant that will supplement the tidal plant.

There has been much theorizing about the development of tidal power, particularly in these days when the cost of coal is high and we begin to realize, as we never did before, that our stores of fossilized fuel cannot last forever. Vast engineering enterprises have been proposed, such as damming the English channel and creating tidal reservoirs along the shores of England and France. These schemes have appealed to the imagination, but we have been wont to look upon them as the extravagant dreams of visionaries. It is therefore with a shock of surprise that we read of a real tidal power scheme of vast proportions actually formulated and fathered by the Civil Engineering Department of British Ministry of Transport. It is proposed to throw a dam across the Severn River about in line with the Severn Tunnel. The Severn at this point has a rise of thirty feet at the time of the spring tides. What the average rise may be, we are not informed. The water as it rises will be let in through the dam and on the ebb-tide will flow back through turbines which will begin operating when there is a head of about five feet. The ebb-tide on the Severn occupies a longer period than the flood-tide and it is estimated that there will be a working period of about seven hours followed by about five hours of idleness. The turbines will generate about half a million horsepower per ten-hour day with a peak output of approximately one million horsepower. About ten miles from the dam a great reservoir will be constructed near the River Wye which runs into the Severn. On the banks of the tidal portion of the Wye River a large pump and power plant will be erected, and surplus power generated by the Severn plant will be used to drive centrifugal pumps at the Wye plant. These pumps will deliver water to the reservoir, which will be located at a high level. Details have not reached us as to the height of the reservoir or its capacity, but it will certainly be of goodly proportions because the water is to be fed to it through a tunnel forty feet in diameter. This tunnel is to be driven through solid rock for a distance of more than a mile. The motors for driving the centrifugal pumps will be arranged to serve as generators when water is fed back from the reservoir. The power of the tidal plant, which is employed in pumping water into the high reservoir, will all be given back except for such losses as are due to the pumping machinery employed and to the friction of the water itself.

It is planned to generate about five hundred thousand horsepower at the Wye plant so that there will be a continuous output of approximately half a million horsepower. This will make the Severn Tidal Plant the largest plant in the world. At Niagara Falls, 675,000 horsepower is now being developed, but this is distributed among a number of different plants on both sides of the river. The Severn should become as large an industrial center as Niagara is today. If more power is generated than can be used in the immediate vicinity of the plant, it can be easily transmitted to more distant localities; in fact it is quite possible that a large portion of the power produced will be stepped up to a high voltage and transmitted as far as London. On the basis of four pounds of coal per horsepower it requires over seventeen tons of coal to produce one horsepower per year, consequently the proposed plant when complete should effect an annual saving of eight and a half million tons of coal.

According to a statement recently made in Parliament the construction of this plant will give employment to ten thousand men for a period of seven years.

The Limits of the Universe*

Recent Researches Which Have Extended Our Concept of the Star-Filled Heavens

By Dr. Svante Arrhenius

President of the Nobel Institute of Physical Chemistry at Stockholm

IN ancient times man believed that our Earth was the center of the Universe and that the starry heavens made a diurnal revolution about it. The great mass of the world was supposed to be constituted of the known parts of the earth and universal space was accordingly very limited. This idea was overthrown by Copernicus, according to whom the Earth, like other planets, describes a very long path about the Sun, while the fixed stars lie outside the solar system. But universal space has acquired far greater dimensions than the men of old ever dreamed of.

According to the Copernican concept, however, the fixed stars apparently were obliged to change their place in the heavens in proportion as the Earth described her orbit. By means of this motion, whose magnitudes were termed parallaxes, it ought to be possible to ascertain the distances of the fixed stars. But Tycho Brahe sought in vain to measure the parallaxes of the stars and found them immeasurably small. It was accordingly supposed by him that either the fixed stars must be immeasurably remote from us or else the earth must be stationary. Tycho Brahe found the second alternative to be the more plausible and, therefore, replaced the Earth in its former position as the center of the universe.

But the majority of the astronomers refused to accept Tycho's reasoning and tried all the harder to measure the parallaxes of the stars. But no one was successful in this until a quarter of a millennium later when Bessel accomplished the feat in 1838 when he discovered a parallax of 0.3 arc-seconds for the star 61 in Cygnus, according to which this star is located at the enormous distance from the sun of 10 light-years or 100 billion kilometers. In the following year Henderson found in Kapstadt that the brilliant star Alpha Centauris is much nearer to us; its parallax was found to resemble an arc-second corresponding to 3.25 light-years, a figure which was later corrected to 4.5 light-years, corresponding to a parallax of 0.75 arc-seconds.

These successful achievements were rightly regarded as a triumph for the science of astronomy. By means of these the measured distances of universal space were estimated to be 100 thousand times greater than those of the solar system whose diameter like that of the orbit of Neptune consists of about 9,000 million kilometers. For it is possible to measure with considerable practical precision stellar distances of cc. 100 light-years. Astronomers busied themselves hereupon in measuring in this manner the stellar universe in every direction. The first great enthusiasm was gradually followed, however, by a certain amount of disillusion. It soon became evident that the star-filled space was far too immense for it to be feasible measure it by the known methods of geometry. It was found, too, that not even a complete thousand among the billions of celestial candles were susceptible of having their location in space determined. The most distant stars in the Milky Way are at far too great a distance to be determined. Thus, for example, the distance of the star cloud in Cygnus is estimated at cc. 25,000 light-years and that of the small Magellanic cloud at cc. 6,000 light-years.

It was necessary, therefore, to invent another method of representing these vast gulfs of space. The great scientist, William Herschel, made statistical measurements of the number of stars in the system of the Milky Way, and was thus led to embrace the view that this system lies within a lens-shaped section of space whose greatest diameter is 850 times that of the average distance of a star of the first magnitude and whose width is only 1/5.5 as great. However, since we cannot determine the aforesaid average distance this estimate is rather indefinite. The celebrated astronomer, Seeliger, has endeavored in recent years to obtain a concept of this expanse by means of a very thorough mathematical handling of the statistical material concerning the star density in the Galaxy. He found that assuming certain hypotheses to be true, its greatest diameter is apparently equal to 50,000 light-years and its smallest diameter to about 10,000 light-years.

Although these calculations are rendered extremely uncertain because of the aforesaid assumed hypotheses, yet they represent a great step in advance with respect to the earlier calculations, among which may be mentioned those of the great physicist, Lord Kelvin, and the distinguished Heidelberg astronomer, Max Wolf, and which result in a computed length of 6,000 to 40,000 light-years for the greatest diameter of the Galaxy.

In any case, however, the majority of astronomers were inclined to believe that the stellar universe is confined to a certain limited extent of space, corresponding roughly to that occupied by the Milky Way. In their view the Sun occupied a comparatively central position within this limited system. In this manner it was possible to agree with Wallace in his view that we might still cling to a fragment of the ancient orthodox Aristotelian theory that man occupies a preferred position in the universe.

Some students of the matter, however, were dissatisfied with these narrow views which rest upon the incompleteness of the determination of the parallaxes, and they, therefore, sought new methods of determining the distances of the heavenly bodies. It was, in fact, determined by a series of measurements that the Sun moves among the swarm of stars with a velocity of cc. 20 km. per second in the direction of Hercules. If the stars were standing still, it would be quite easy, of course, to determine their distances by means of their *apparent* movements resulting from the motion of the sun.

If we take into consideration, however, a very large number of stars it is probably safe to assume that they are standing still on the average. In this manner a number of astronomers and, particularly, the famous Hollander, Kapteyn, have ascertained the average distance of various systems of stars and have obtained very interesting results.

It would be far more instructive, however, if we were able to ascertain the distance of the individual stars. For this purpose a method has been employed which has been used for unknown ages to determine distances from the earth. When we know the size of an object, e. g., of a house, a tree, or a man, and either measure or estimate the angle formed by this object with the line of vision, it is possible to estimate the distance of the said object. For example, the distance of a given man is estimated in this manner as a military exercise. Applied to the stars the method is employed as follows:

We assume that all the stars of the same system possess equal magnitudes, and that their surfaces are likewise equally luminous. It follows from this that a star belonging to a system located at a distance of 20 light-years is only ¼ as brilliant as a similar star at a distance of ten light-years. But the comparative intensity of the light of a star can readily be determined, partly by observation with the eye, in which case it is compared with the luminous intensity of some nearby star which has already been measured, and partly also from the *blackening of a photographic plate caused by the image of the said star*, in which case the said image is likewise compared with that of a known star recorded upon the same

* Translated for the SCIENTIFIC AMERICAN MONTHLY from *Die Umschau* (Frankfurt) for September 25, 1920.

plate. These two methods of determining luminosity do not yield the same figures, since *the redder (or colder) a star is the smaller its photographic luminosity compared with its visual luminosity.* This difference between visual and photographic brightness plays a great rôle in astronomy as we shall see, and it has, therefore, been given a name of its own, i. e., the *color index.* In the case of the white hydrogen-stars which are listed in the catalogue of the Harvard Observatory at Cambridge, Mass., under the sign A_0 the color index is O; in the case of the red star, the M. star of the same catalog, it corresponds to two classes of magnitudes.

When now it happens that a few such stars lie sufficiently near us for their parallaxes to be determined, so that their distance in light-years is known, then the distance of the others can be computed from the intensity of their luminosity, since the latter is proportional to the square of the distance. It was in this manner that Charlier computed the distance of the Helium Stars which are listed in Harvard Catalog under the letter B from a provisional investigation by means of the Kapteyn method. The result was, however, that these must be divided into two subordinate groups, one of which is designated with the letters B_1 and B_2 while the others are listed under B_0, B_3, and B_5 in the Harvard Catalog. As a result of the Charlier researches it was discovered that these groups of Helium Stars form an exceedingly limited collection, which is strongly concentrated about the plane of the Milky Way and whose middle point lies at a distance of about 320 light-years from us and whose greatest diameter is about ten times as large. They are enclosed between two planes, which lie at a distance of about 1,000 light-years apart from each other. This group forms a cluster of stars having about the same dimensions as those of the Milky Way as computed by Kelvin. Charlier was also of the opinion that this formation is to be regarded as a sort of skeleton of the system of the Milky Way. However, the Milky Way is far greater in extent, as has been proved by later investigators, and the Helium Star groups of Charlier are now commonly called "the local star groups." Our own Sun and the overwhelming majority of the visible stars lie within this group.

A very admirable *method of determining the absolute magnitude of a star* and thereby of finding its distance, since the magnitude seen by us is known, was invented in 1917 by Adams at the Mount Wilson Observatory. He investigated the relative intensity of certain lines of the spectrum and the absolute luminous intensity of about 100 stars, whose distances are known to us exactly. He found that the *absolute luminous intensity* of these stars can be computed with great exactness from the behavior of the *lines of the spectra* examined. In this manner it is possible to calculate the absolute luminous intensity of a star whose distance cannot be determined by means of the measurement of the parallax, and thus the distance can readily be computed. This Adams method is not adapted, however, for application to the white stars or to stars which are fainter than those of the tenth magnitude. Dr. Lindblad of Upsala has suggested a modification of this method in which the location of the maximum of luminosity in the normal spectrum of the star in question, and the location of the extreme ultra-violet portion of the spectrum are determined. By the aid of this adapted method it has been possible to determine the distance of stars even as remote as the seventeenth magnitude, although the degree of precision is not so great as in the Adams method. By means of this method the distances of the star-nebulae which belong to the Milky Way have been measured. Thus, for example, the stellar nebula in Auriga has found to be at a distance from us of about 5,000 light-years, that in Cygnus at about the same distance, and that in Aquila at about 17,000 light-years. According to this the Milky Way presumably forms an immense spiral with a diameter of from 50 to 100 thousand light-years.

Since the earliest historical times the attention of human beings has been strongly attracted by certain so-called *open star clusters,* such as the Pleiades and the Hyades. From the movements of these star clusters Kapteyn calculated their distance at from 220 to 130 light-years. Shapely, whose researches in this domain are of extraordinary value calculated by means of the Adams method, the position of 70 such clusters and found that the two which are nearest to us are the aforesaid Hyades and Pleiades, which form an exception in that the cluster which follows them in Dreyer's New General Catalog, No. 3532, is at a distance of 1300 light-years from us. It lies only 32 light-years to the north of the middle plane of the Milky Way. The farthest from us of these celestial objects bears the number 6005 in the above catalog and lies at a distance of about 55,000 light-years from us and of only 3600 light-years to the south of the middle plane of the Galaxy. These researches have led to the conclusion that these formations lie closely crowded about this middle plane. Hence they undoubtedly belong to the Milky Way, and their diameter is, according to these measurements, of about the same magnitude, i. e., about 100,000 light-years as was obtained from the calculation of the distances of the stellar nebulae. Hence the system of the Milky Way is according to this about thirty times as great an extent as the local star cluster of the helium stars.

A still greater sensation was produced by Shapley's measurements of the distances of the changeable stars, which have obtained the name of Cepheides from the star Delta Cephei as well as of the enormous masses of stars which have received the names of globular or closed star clusters. Shapley discovered that the redder the color of one of the Cepheides and the longer the period of its alternation of light, the greater its luminous intensity. With the help of these two circumstances he was able to ascertain the absolute luminous intensity and likewise the distance of these marvellous stars. He found it convenient to divide them into two principal classes according to whether their period is more than 24 hours or less. Those having the long periods are giant stars, whose absolute luminous intensity is from 200 times to 10,000 times as great as that of the Sun. Their movement in the direction of the line of vision can be measured as we know by means of the spectroscope. It averages less than 10 km. per second. They are massed very densely in the vicinity of the middle plane of the Milky Way. They evidently belong to the system of the latter and lie comparatively near us—the farthest one known to us being at a distance of cc. 20,000 light-years.

The Cepheides having short periods lie at about the same distance, but they are distributed in an almost uniform manner around the Sun. Those few among them, only four, whose velocity we have thus far been able to determine, are *rushing,* according to Adam's measurements, *with furious rapidity through celestial space.* Their velocity in the line of vision varies from 52 km. to 196 km. per second. Their luminous intensity is on the average "only" a little bit more than 100 times as much as that of our own Sun. Even these fainter stars among the Cepheides unquestionably belong to the Milky Way.

The Cepheides possessed a peculiar interest for Shapley because of the fact that such stars are found in the singular globular star clusters which often contain millions of stars, and which, to judge from the luminous intensity of these lie at a great distance from us. The various Cepheides found in the same star clusters have an almost equal power of illumination, whereas this is very different, on the contrary, in other star clusters. This is naturally due to the fact that the star clusters do not all lie equally near to us. By the aid of the Cepheides, Shapley determined the distance of those star clusters in which such variability occur. For this purpose he made use only of those having a period of less than 24 hours. Since, however, such stars do not occur in very many star clusters, he compared the power of illumination of the brightest non-variable stars with that of the Cepheides in those star clusters where they are present. He found that the former possesses upon the average 3.53 times as great a power of

illumination as the latter. By the aid of this figure he was able, therefore, to calculate also the distance of those clusters which contain no Cepheides. He made use of yet a third method, according to which he assumed that all star clusters having the same cluster diameter possess about 65 light-years. The results obtained by these three methods coincided admirably.

The globular star clusters form a system whose greatest diameter is, at least, 300,000 light-years, and whose middle point is about 65,000 light-years distant from the Sun. The one nearest to us, Omega in the Centaur, lies at a distance of 23,000 light-years from us, while the farthest which is number 7006 in the New General Catalog, is 220,000 light-years distant. These clusters are located symmetrically around the middle plane of the Milky Way, so that they are very seldom to be found in the neighborhood of the Galactic Pole. It is a remarkable fact that they are almost entirely lacking between two planes which lie at a distance of 6,000 light-years from the middle plane of the Milky Way. This has led Shapley to conclude that they possess a genetic connection with our own Milky Way system. As a general thing they are moving toward us (this being found to be true in seven out of ten cases which have been studied) with an enormous velocity which averages about 144 km. per second. Two of them are traveling away from us, one at a rate of 225 km. per second and the other at 10 km. per second. One of them possesses so slight a motion, as compared with ourselves, that it is to be regarded as practically stationary.

Charlier has assumed that since the globular star clusters are located in the vicinity of the Milky Way, they must belong to the latter, and is of opinion, therefore, that they lie at the same comparatively small distance from us, as do the helium stars studied by him, i. e., at less than 2,000 light-years, whereas, according to Shapley their distance is 100 times as great. Such a disagreement as this between two learned doctors caused astronomers to welcome a new calculation of this magnitude. This was made by Dr. Lundmark, in Upsala, partly by the application of other bases of calculation than those employed by Shapley. He found Shapley's results completely confirmed.

But Lundmark did not content himself with the confirmation thus obtained. He went a step further and sought to determine the *distance of the spiral nebulae* which are crowded most densely about the pole of the Milky Way. He took as a starting point the new stars which have appeared in some of these clusters, especially the most beautiful among them, the long known Andromeda Nebula. He compared the luminous intensity of these with that of the brightest of the "new stars" in the Milky Way, concerning which he assumed by reason of certain known facts, that they are upon the average as far distant as are the stars of the thirteenth magnitude. In this manner he found the distance of the nebula of Andromeda to be about 600,000 light-years. According to this its diameter would be 20,000 light-years, or about seven times as great as that of the local group of B stars. The Magellan nebulae would, according to this, also be nebular structures lying much nearer to us, namely, at a distance of about 60,000 light-years. Their diameters are two to three times as great as that of the local group.

But Lundmark has proceeded further still, starting with the assumption that other visible nebulae are approximately of the same magnitude as the nebula of Andromeda. This leads him to the conclusion that the average distance of these *nebulae* observed by him attains upon the average *the dizzy figure of about twenty million light-years.*

Lundmark found a few single stars standing out conspicuously in the Andromeda Nebula and in the magnificent nebula marked No. 33 in Messier's Catalog (in the star cluster of Triangulum). Assuming that these stars are as brightly luminous as those which exhibit the greatest luminous intensity in the Galaxy, he calculated that the distances of the aforesaid formation must be about 500,000 and 1,600,000 light-years. The first named figure agrees admirably with the one cited above for the nebula of Andromeda. Hence we are justified in concluding that Lundmark's calculations must be approximately correct.

By means of these recent researches our human concept of the star-filled heavens is vastly extended afresh as it was at the beginning of modern times by the genius of Copernicus. The development of the science has been so tremendously rapid in the 20th century, and especially in the last five years, that we can but expect that many details are subject to alteration and that others are yet to be discovered, by means of which the already proud results of these researches will gain in perfection and in beauty.

Infinity is, indeed, immeasurable, so that we shall never be able to prove definitely that the *universe is infinite in space as well as in mass*, but the millions of years of light-years with which our vision has been so suddenly enriched, would indicate that *no bounds are set to the spirit of research, except those which are involved in the imperfection of our tools.*

RECENT STUDIES OF THE MILKY WAY

THE always fascinating subject of the Milky Way has been the subject of fresh research during the last few months and some interesting discoveries are announced as a result thereof. The well-known Swedish astronomer, C. V. L. Charlier, in an address delivered before the Physical Society in Copenhagen, Denmark, in December, 1920, referred to some extremely important research being done concerning the Galaxy at the Lund Observatory. The work now in progress is based on a star map worked out by Prof. Wm. H. Pickering of this country and the English astronomer, Franklin Adone.

According to a special cable published in the New York *Times* of December 14, 1920, Prof. Charlier declares the work is already so far advanced that it is possible to state definitely that when it is completed it will be demonstrated that the sun is situated at one end of the Milky Way instead of in the center as has been heretofore supposed. It will be proved furthermore that instead of having a lenticular form the Milky Way is an ellipse whose major axis is directed toward the constellation Sagittarius.

Meanwhile the spectrum of the Milky Way has been the subject of special study in this country. While knowledge of the spectral type and motion of all the stars found in the Milky Way is today regarded as having an important bearing on the general study of our sidereal system the magnitude of the task of acquiring such comprehensive knowledge is somewhat appalling. It is quite possible, however, to obtain information concerning the predominant spectral type of the integrated light of the stars by treating the Galaxy as a luminous surface. For this purpose a spectrograph alone is sufficient.

Mr. V. M. Slipher read a paper upon this topic before the twenty-third meeting of the American Astronomical Society, a report of which we find in *Popular Astronomy* for December, 1919. He states that some preliminary observation along this line have been made at Flagstaff, Arizona. In these use was made of a spectrograph having a high light-power and sufficient dispersion to show plainly the chief features of the various spectral types. Observations of two regions were made—one in Sagittarius and one in Scutum—and lantern slides of the results were exhibited.

The spectra of the two regions were found to be similar, both showing in a very marked manner the main features of the solar type spectrum. However, it is revealed upon closer inspection that there are present stronger hydrogen lines than belong to the said type. Hence the spectrum would be termed "composite" with a predominance of the solar light. As a matter of fact, this result has been the cause of some surprise since studies of the brighter stars had given rise to the idea that the fainter stars of the Milky Way were of the first type. This result is in accord with that of Fath, who found the spectrum to be approximately of the solar type.

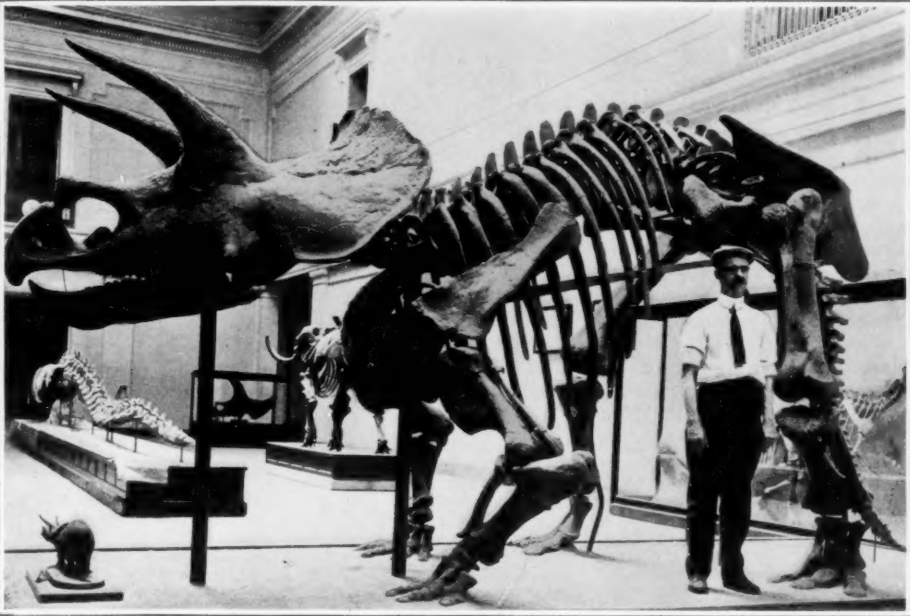


FIG. 1, SKELETON OF THE HORNED DINOSAUR *TRICERATOPS* NOW ON EXHIBITION AT THE NATIONAL MUSEUM. AT THE RIGHT, FIG. 2, A COMPARISON OF THE SKULL OF A HORNED TOAD (ABOVE) AND A HORNED DINOSAUR, *STYRACOSAURUS* (BELOW).

A New Horned Dinosaur from Canada

The *Styracosaurus Albertensis* with a Six-Foot Skull Bristling with Horns

By Charles W. Gilmore

Associate Curator, U. S. National Museum, Washington, D. C.

THERE has been discovered in the breaks along the Red Deer River in the Province of Alberta, Canada, the most remarkable example of an extinct Horned Dinosaur that has yet been brought to the attention of science. *Styracosaurus albertensis* as this animal has been called by the late Mr. L. M. Lambe, Chief Paleontologist of the Geological Survey of Canada, is known only from the skull, as the other parts of the skeleton were destroyed before the skull was discovered.

The skull of *Styracosaurus* is over six feet long with a great horn above the center of the nose that is nearly twenty inches high and six inches in diameter at the base. Most striking, however, is the development of six horn cores that radiate from the crest of the skull, as shown in Fig. 2, a top view of the head, which at its broadest part measures four and one-half feet across. The central pair of horn cores, which are the largest, are twenty-two inches long, the next pair twenty and the outer pair fourteen inches, respectively. In life all of these horn cores were covered with a horny skin, which probably somewhat increased their length. The name *Styracosaurus* is in reference to these bony spikes which must have made this reptile a veritable moving *chevaux de frise*.

Horned dinosaurs so far as known at the present time are only found in North America, and it was in 1887 that the first specimen consisting of a pair of large horn cores was uncovered in making an excavation in the suburbs of Denver, Colorado, and these so resembled the horns of the extinct bison that Prof. O. C. Marsh in writing of the discovery gave it the name of *Bison alticornis*, but two years later the discovery of complete skulls having similar horn cores showed it to be a reptile instead of a bison much to the discomfiture of the professor. This specimen is now preserved in the collections of the National Museum in Washington. It was the first of a long series of discoveries which through scientific and popular descriptions have made the horned dinosaurs familiar to the world. Although many different kinds of these horned reptiles are known the Canadian specimen tops them all in the ornateness of its skull decorations.

In Fig. 3 is shown a restoration of the head of *Styracosaurus*, based on the skull which was modeled by the author and depicts his conception of the probable life appearance of this animal.

There is a mistaken notion that extinct animals and especially the dinosaurs have a corner on all that is unusual in size and grotesqueness of form. In the matter of size the dinosaurs such as the huge *Brontosaurus* and its allies were the largest land animals the world has ever known, but in bulk probably none of these exceeded in weight the whales of the present day. In the matter of appearance it must be borne in mind that many of the striking peculiarities of the dinosaurs are enhanced by their great size and this is true of *Styracosaurus*, for when the skull of this animal is compared with that of the living "horned toad" (*Phrynosoma*), see Fig. 2, which by the way is not a toad at all but a lizard, a striking resemblance is to be observed. This resemblance is not so much in the shape of the skulls as in the similarity of their horny decorations. Should the skull of *Phrynosoma* be enlarged 72 times, for it is only an inch long, in order to bring it up to the same size as the *Styracosaurus* skull it would be even more bizarre in its appearance than the head of that animal.

The discovery of this fossil specimen by Mr. Charles H. Sternberg is interestingly told in his book, "Hunting Dinosaurs on Red Deer River, Alberta, Canada." He says: "On the 19th of September I made the discovery of the strange spiked dinosaur, called by Mr. Lambe *Styracosaurus*. The ground was wet with repeated showers. The fossil beds are not safe then, as one slips as if walking on soft soap. There is much clay in all the rocks; in fact more than half of them

are made up of clay, interlaid with silver gray sandstone, also containing much clay. However, I could not idle about camp and made the attempt to get in the badlands, walking up the bed of a long coulee that was filled with boulders. I got to where it was extremely difficult, as the bed was narrow and crooked, but at last reached the head. Many other ravines headed near by, and in going over to one of them I saw in the steep slope of a narrow gorge, in gray sandstone, the skull that is shown in Fig. 2. It was 200 feet below the prairie, and it required a great deal of labor to collect and load it in the wagon. It was packed securely in a box, after it had been carefully wrapped in burlap dipped in plaster, and secured with strong poles to hold it together. A road was cut in the face of the cliff, and our faithful team hauled the box weighing about nine hundred pounds out of the ravine; they often fell down and cut themselves, but they scrambled up the narrow road with their burden fastened to a sled. When they got to the level prairie the boys let the hind wheels into the ground to the hubs and rolled the box in. The skull was partially prepared by me the next winter."

This specimen now forms an interesting part of the exhibit of fossils in the Victoria Memorial Museum in Ottawa, Canada.

FIG. 3. RESTORED HEAD OF *STYRACOSAURUS* MODELLED BY CHARLES W. GILMORE

Although as yet nothing is known of the body part of the skeleton there is every reason for believing that when found it will resemble in form and bulky proportions the mounted skeleton of the horned dinosaur Triceratops now exhibited in the United States National Museum as shown in the illustration (Fig. 1). This specimen with a skull six and one-half feet long measures about twenty feet in length over all, and stands about eight feet high at the hips.

The horned dinosaurs were the largest headed land animals of which we have knowledge, some of the skulls of old animals attaining a length of over eight feet. Although having such immense heads the brain is smaller in proportion to it than in any know vertebrate animal, being but little larger than a man's fist. The back part of the skull rises up into a kind of bony crest or frill as it is usually called, an arrangement doubtless effective as a protection to the vital parts of the neck.

After the many attempts of the horned dinosaurs to perfect their organization in order to bring it into harmony with their surroundings it seems rather hard that they should have been exterminated, but all things have their day, even dinosaurs.

THE USES OF TALC AND SOAPSTONE

WHILE talc is usually associated in the average mind with cosmetics there are a large number of applications which are little known and some of them not fully developed. The uses of talc and soapstone made the subject of a summarized list of present and possible future uses by R. B. Ladoo in *Chemical and Metallurgical Engineering*, October 11. Considerably more attention has been called to the technology and utilization of talc in Germany and Austria than in this country according to the author, notwithstanding the fact that the United States produces 65 per cent of the world's talc and Germany and Austria only 5.4 per cent. The Talc and Soapstone Producers' Association have decided to supply funds for research into the properties and uses of talc and as a result it is hoped that markets may be broadened. The list indicates the general specification under each head while we give here only the principal uses of powdered talc and soapstone, 57 of them:

Paper manufacture
Roofing paper manufacture
Textile manufacture
Rubber manufacture
Paint manufacture
Soap manufacture
Foundry-facing manufacture
Toilet preparations
Wire-insulating compounds
Lubricants—Liquid or grease
Linoleum and oilcloth manufacture
Pipe-covering compounds
Pottery and porcelain
Electrical insulation
Rope and twine manufacture
Leather manufacture
Cork manufacture
Oil manufacture
Glass industry
Portland cement and concrete
Wall plaster
Asbestos industry
Manufacture of crayons, plaques and blocks
Preservative coating on stonework
Cleaning and polishing rice, peas, coffee, beans, maize, barley, peanuts and other similar foodstuffs
Bleaching barley grain of inferior color
Rubber stamp manufacture
Composition floor manufacture
Insulating material for switchboards, floors of generating stations, etc.
Imitation stone
Boot and shoe powder
Glove powder
Dermatology
Absorbing colors of animal, plant and artificial origin
Veterinary surgery
Purification of waste waters
Manufacture of water filters similar to Berkafeld
Conserving fruits, vegetables and eggs
Sugar refining
Contact material for catalytic reactions
Absorbent for nitroglycerine
Packing material for metallic sodium and potassium
Fireproofing wood
Acid-proof and fireproof packing and cement
Automobile polish
Fertilizer manufacture
Agriculture
Shoe polish and cleaner
Yarn and thread manufacture
Chemical—Pharmaceutical industry
Colored crayons
Stove polishes
Imitation amber
Cleaning and glossing of hair and bristles
Floor wax
Terrzzo or Mosaic flooring
Candy manufacture

The uses for massive talc and soapstone are presented as follows: Lava blanks for electrical insulation, gas burner tips, etc., crayons, pencils and special chalk such as tailors' chalk, refractories, glass making, and metallurgical industries, as a polishing agent for cooking utensils and in the form of blocks for carving, while slabs enter into the construction of hoods, tanks, sinks, and many domestic appliances.

AID FOR THE INDIAN POTTERY INDUSTRY

THAT the Bureau of Standards assists all the people in the country whenever it can is strikingly shown by the assistance which it rendered lately to the Hopi Indians in the manufacture of their pottery. This pottery is shipped to a considerable extent and has quite a wide sale, but, unfortunately, it is very fragile and has been subject to breakage. The Bureau has endeavored to determine the best manner for increasing the durability of the pottery and has still more recently undertaken to develop a black stain which will be superior to the kind previously used by the Indians. A stain has been produced which is very much better than the one at present largely used by the Indians and has the advantage that it produces a good color and can be made from very cheap materials. As a result of this work, a similar request for assistance has been received from the Zuni Indians of New Mexico.

FIG. 1. SQUARE TOWER HOUSE EXCAVATED AND REPAIRED AS SEEN FROM THE SOUTHWEST
Photograph by Fred Jeep

Excavating Cliff Dwellings in Mesa Verde

Unique Structural Features of the Kivas of Square Tower House and Discovery of New Ruins

THE field-work of Dr. J. Walter Fewkes, Chief of the Bureau of American Ethnology, at the Mesa Verde National Park, in the summer of 1919, was devoted to the excavation and repair of the picturesque cliff dwelling, Square Tower House, known for many years as Peabody House, and two low prehistoric mounds situated among the cedars on top of the plateau. This work was a continuation of that of previous years and was carried on in coöperation with the National Park Service of the Department of the Interior. As Square Tower House has several unique structural features, the summer's work has added to the educational attractions of the Park. At least two new types of hitherto unknown small-house ruins were discovered, and it is believed that a new page has been added to the history of the Mesa Verde cliff people. Dr. Fewkes was assisted in his field-work by Mr. Ralph Linton, a temporary assistant, who contributed much to the success of the work.

The main object was to gather data that may aid one better to comprehend the Indian civilization that arose, flourished on the Mesa Verde, and disappeared from the plateau over four centuries ago.

Square Tower House is situated in a shallow cave at the head of a spur of Navaho Canyon opposite Echo Cliff, about 2 miles south of Spruce Tree Camp. It has long been considered by tourists one of the most atractive cliff dwellings of the park, but its inaccessibility has deterred all but the most venturesome from descending to it from the rim of the canyon. Part of the old Indian trail was indicated by shallow foot holes cut in the almost perpendicular cliffs, and previous to the past summer this was the only means of access. Without mutilating the vestiges of this primitive trail another was made in the cliff near it, around which was constructed a balustrade with ladders conveniently set to aid those who wish to visit the ruin.

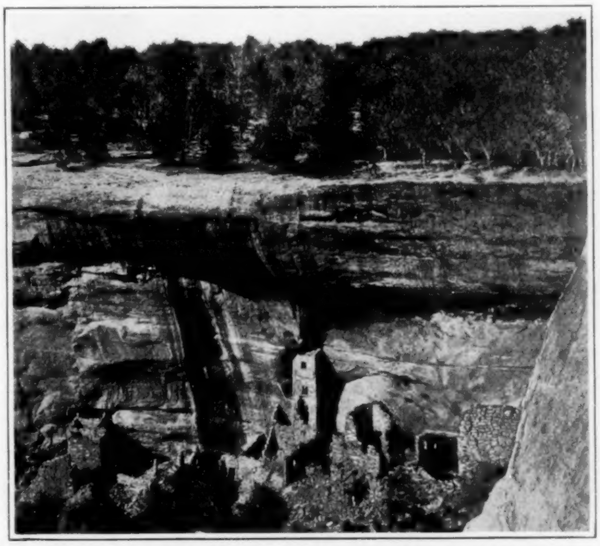


FIG. 2. SQUARE TOWER HOUSE BEFORE EXCAVATION AND REPAIR, FROM CANYON RIM

Square Tower House (Figs. 1 and 2) measures 140 feet in length and averages three stories high, with seven circular subterranean sanctuaries or kivas. The floor of the eastern end of the cave is composed of large boulders fallen from the roof; that of the western end is lower and comparatively level. The original entrance to the building, like that of the Cliff Palace,

*From *Smithsonian Miscellaneous Collections*, 1920, Vol. 72, No. 1, pp. 47-64.

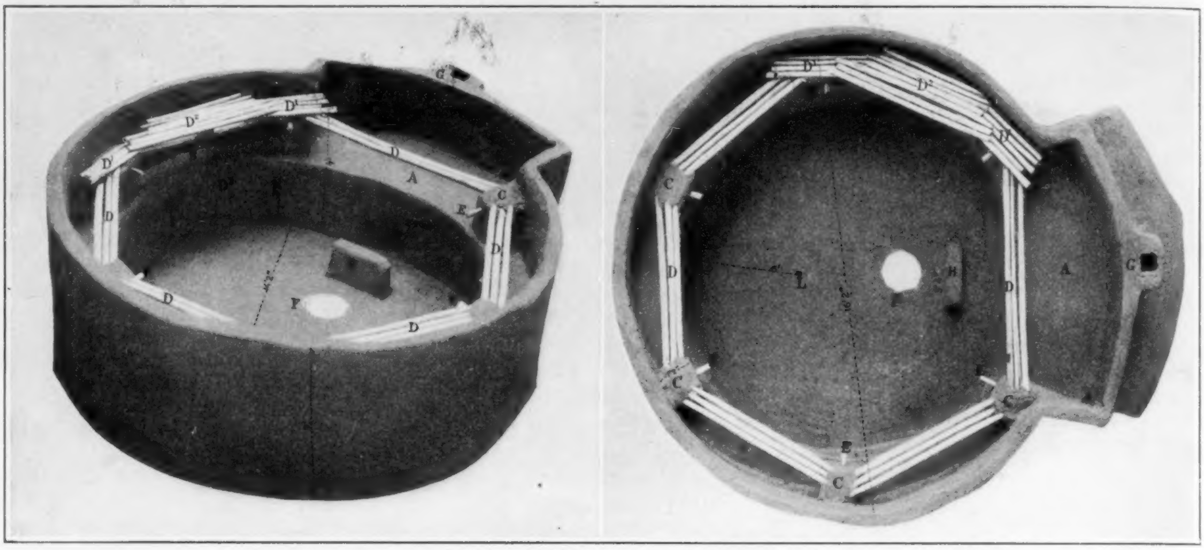


FIG. 3. MODEL OF A TYPICAL PREHISTORIC KIVA OF THE PURE PUEBLO TYPE

The photograph shows the model from above (*right*) and from the side (*left*), with first roof beams in place. A, large banquette; *B*, small banquettes; *C*, pilasters to support roof cribbing; *D*, beams of lower level of roof; D^1, beams of second level of roof; D^2, beams of third level of roof; D^3, logs to prevent sagging of roof; *E*, pegs for ceremonial paraphernalia; *F*, fire hole; *G*, external opening of ventilator; *H*, fire screen, or pure air deflector; *I*, niches for sacred meal; *K*, floor entrance to ventilator; *L*, ceremonial floor opening or *sipapu*. Photographs by De Lancey Gill.

Far View House, and Sun Temple, is a recess in the front wall. On the western end of the ruin there protrude radiating walls of basal rooms, one story high, suggesting a terrace. The rear wall of the cliff rises almost perpendicularly from the floor with no recess back of the buildings. The destructive effects of water dripping from the canyon rim are most marked midway in the length of the building where the walls (Fig. 1) now reduced to their foundations, were formerly at least two stories high.

The walls of the ruin were in bad condition when the work began: great gaps in the masonry of the tower having rendered it in danger of falling. The interiors of the rooms were choked with fallen stones and the dust of ages. Two months given to excavation and repair have put the ruin in fine condition, exhibiting a good example of the best type of Pueblo architecture. The special attractions of Square Tower House are the remains of the roofs of two kivas and the high tower rising midway in its length.

The original roof beams (Fig. 5) of these two kivas are almost wholly intact. Considering how few kiva roofs on the mesa have survived destruction in the lapse of time, especial care was exercised to preserve these and to indicate their mode of construction, and a model has been made, photographs of which, in successive stages of construction, are given in Figs. 3 and 4. A good understanding of the construction of a typical kiva is especially important, as it distinguishes cliff houses of the Mesa Verde from those found elsewhere in the Southwest as well as in foreign lands.

The kivas of Square Tower House are circular, subterranean in position, and entered by a hatchway. Each kiva has a fire hole *F*, and near it an opening in the floor called the sipapu, *L*, which is very sacred because it symbolizes the

FIG. 4. MODEL OF TYPICAL KIVA OF THE PURE PUEBLO TYPE

Construction of roof beams is shown at the right, and the half-covered roof and hatchway at the left. Photographs by De Lancey Gill.

entrance to the underworld. Over it in Hopi ceremonies is erected the altar, and through it the priests call to their kin in the underworld. A most instructive feature in the structure of the kiva is the means of ventilation. Between the fire hole and the wall there is an upright slab of stone, *H*, a wall of masonry, or simply upright sticks covered with clay. The function of this object is to deflect pure air which enters the room from a shaft opening outside, *G*; the ventilator is morphologically the survival of the doorway of the earth lodge or prototype of the kiva. A characteristic feature of the kiva is the roof, which rests on six mural pilasters, *C*; the intervals between which are called banquettes, *B*, that (*A*) over the ventilator being wider and broader than the others. The pilasters support logs, *D*, D^1, D^2, laid one above another in the form of cribbing. Short sticks, D^3, are placed at right angles to the cribbing to prevent sagging. Upon this cribbing are laid logs over which is spread cedar bark to support the clay covering the roof. The hatchway, which also served for the passage of smoke, is situated in the roof above the fire hole. In the construction of this roof, men of the Stone Age in America were not far from the discovery of the principle of the dome.

FIG. 5. VIEW FROM BELOW OF ONE SECTOR OF ORIGINAL ROOF LOGS OF KIVA A
Photograph by Gordon Parker.

The most striking feature of Square Tower House is the tower from which it takes its name. The cave in which it is situated having no recess at its back, there is consequently no refuse heap in the rear, such as was utilized at Spruce Tree House for mortuary purposes. The rear wall of the tower is formed by the perpendicular cliff (Fig. 6). As shown by windows, doorways, and remnants of flooring, this tower is four stories high. The inner plastering of the lowest story is painted white with a dado colored red; its roof is likewise well preserved.

A room near the western end (Fig. 9) of the ruin has doors and windows closed with secondary masonry, and in the rubbish, half filling the neighboring kivas, human bones were found, indicating that the western end of the ruin was deserted and used for mortuary purposes before the ruin itself was abandoned.

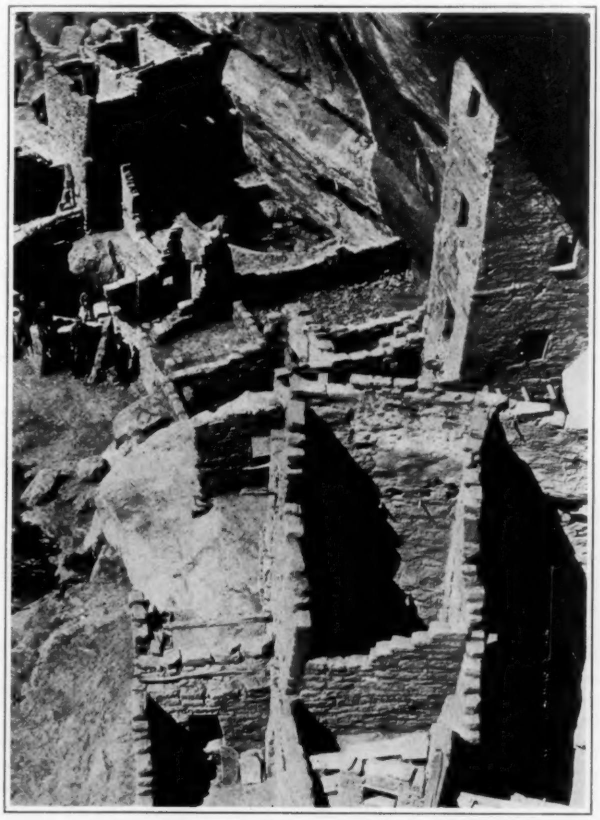


FIG. 6. MIDDLE SECTION OF SQUARE TOWER HOUSE FROM THE CROW'S NEST
Photograph by Fred Jeep.

There is no archeological evidence that the tribes to the east, north and west of the cliff dwellers and stone house builders of the Pueblo area were stone masons. On the south of the area, in the valley of the Gila, Santa Cruz, and San Pedro, looking toward Mexico, the ancients built their houses of earth and logs, and while the prehistoric buildings on the southern tributaries of the San Juan resemble those on the Mesa Verde they are quite different from the pueblos now inhabited. A logical interpretation of the geographical distribution of ruins with kivas like those of Square Tower House would not be that the knowledge of stone masonry was introduced from Mexico, but that the craft was acquired after the original inhabitants entered the country, and that the pure pueblo type, or that with kivas like those of Square Tower House, was born, cradled, and reached its highest development in the area where it was found. But we may take another step, and point out that the prototype of these prehistoric kivas has a morphological likeness to "earth lodges."

The discovery of Earth Lodge A in this area by my assistant, Mr. Ralph Linton, was important, considering the light it may throw on the genesis of cliff dwellings. This ancient prototype (Fig. 7) of a kiva is a semicircular isolated room with a slightly depressed floor in which is a centrally placed firepit, the surrounding walls being either adobe plastered on the earth or molded into clumps shaped like rolls. In this rude sunken wall were set at an angle posts, now charred at the free ends, all that remains of the supports of roof and sides.

Earth Lodge A was not only excavated but a shed was built over it for permanent preservation. While it is interpreted as the prototype of a kiva, it was formerly the dwelling of a family or other social unit dating to an epoch much older than that of the cliff dwellers. On opposite sides of the fire hole at the periphery of the floor, but within the outer walls, are small square or rectangular cists made of stone slabs set on edge. The indications are that these were covered with sticks and clay, suggesting the so-called slab houses. The pottery found in these cists is very crude, undecorated, and not of cliff house type.

There are many sites resembling that of Earth Lodge A before excavation awaiting

investigation on the top of Mesa Verde. Near it was a mound which when opened proved to be a unit-type house. The crude masonry and rough pottery found in it indicate an advance on the walls of an earth lodge, but the former is inferior to that of a kiva of the highest development, suggesting that it is an intermediate form between Earth Lodge A and Square Tower House. The spade revealed that after this room was first deserted débris had filled the depression a few feet deep on which a new fire hole and a grinding bin had been made of stone slabs on edge in the middle of the depression. Later on it was again abandoned and human bones had been thrown on the débris that formed over the grinding bin, indicating that the depression had become a dump place. Last of all, these were also covered by accumulated sand and soil, leaving only the top stones of a pilaster projecting above the surface.

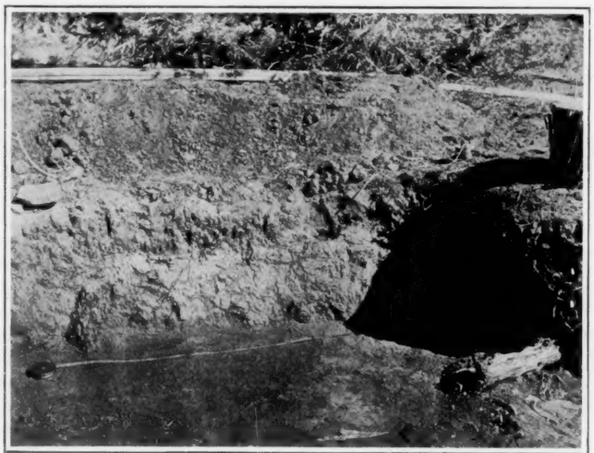


FIG. 7. WALL OF EARTH LODGE A. SHOWING ADOBE PLASTERING ON EARTH; THE HORIZONTAL LOG IS A ROOF BEAM
Photograph by T. G. Lemmon.

FIG. 8. IDOL OF THE GERM-GOD SET BY AUTHOR IN CEMENT AT HEAD OF THE STAIRWAY, NEAR KIVA B
Photograph by Fred Jeep.

The pottery found in this crudely constructed kiva is more varied, but still an advance on that excavated in Earth Lodge A. It may be classified as black and white, and corrugated, but so inferior to that typical of cliff houses that it can be readily distinguished. From this ruin was taken a shard with a fine swastika, showing the antiquity of this design so rarely found in Mesa Verde.

The general facies of the collection of artifacts from Square Tower House is the same as in other cliff dwellings on the park, and although a few specimens are different from those already known, the majority corroborate, as far as age is concerned, the testimony of the buildings. A broken fragment of the rim of a vase of the sugar bowl pattern, a type peculiar to the upper San Juan area, was obtained from the Unit-Type House. Fragments of food bowls corrugated on the outside, black and white on the interior, belong to a type hitherto rare. No collector has thus far reported a prehistoric pipe from Mesa Verde, but a stumpy straight tube of unburnt clay, more like a "cloud blower" than a pipe, betrayed the fact that the cliff dwellers, like other Indians, smoked ceremonially.

On their altar at the great winter solstice ceremony at Walpi, one object of which is the increase of life by calling back the sun, the Hopi now employ an idol representing the god of germination. This idol is half oval in shape, the surface being painted with symbols of corn. A similar undecorated idol (Fig. 8), found at Square Tower House, one of the best ever collected, was cemented by the author in a conspicuous place at the head of the stairway.

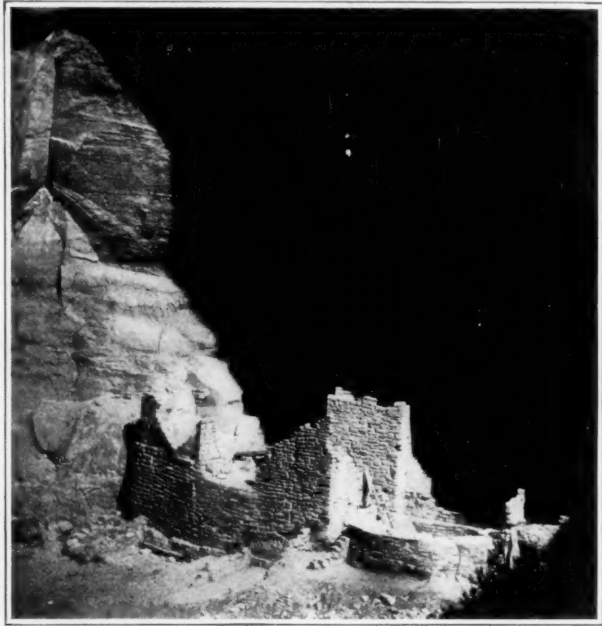


FIG. 9. WESTERN END OF SQUARE TOWER HOUSE, EXCAVATED AND REPAIRED
Photograph by Fewkes.

An almost perfect reed mat, resembling those often deposited with the dead, was found in a room of Square Tower House. Good specimens of feathered cloth were wrapped around skeletons of infants. A fine pottery rest (Fig. 10), and a stick which shows excellent carving on one end (Fig. 11), occur in the collection; there are also many bone needles, basket fragments, and other objects similar to those elsewhere described.

A cubical stone with an incised design (Fig. 12) found in the same room as the idol of the germ god, is worthy of special mention as the maze or labyrinth depicted upon it is unlike any pictograph yet described from the Southwest.

Theoretically, Earth Lodge A is supposed to resemble forms of dwellings that have survived to our day among non-pueblo tribes. It has, however, an instructive feature they do not possess, viz., cists made of slabs of stone set on edge. Evi-

dences are accumulating of a culture antecedent to the pure pueblo type in which vertical masonry predominates, but we must wait more knowledge of the construction of the houses of this epoch before speculating on the early relations of the builders of vertical and horizontal masonry.

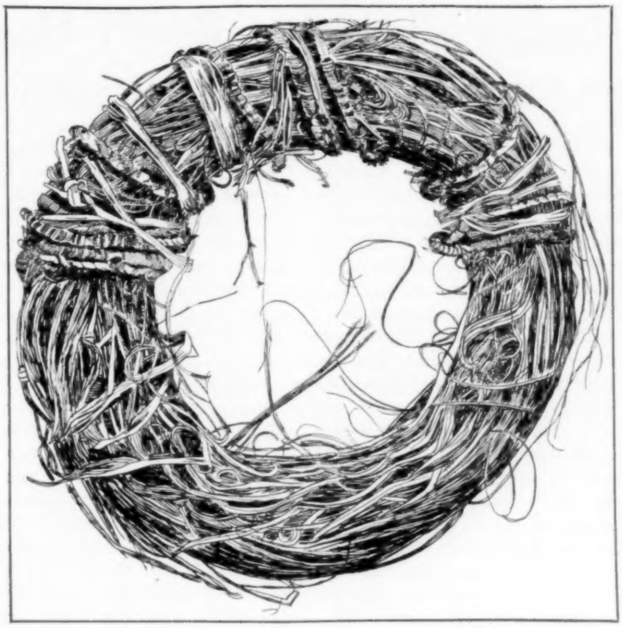


FIG. 10. POTTERY REST MADE OF AGAVE FIBER CORE WOUND WITH FEATHERED STRING

THE VOICE OF THE DEATH'S HEAD MOTH *

ONE of the minor problems of zoology which has been much debated is the means whereby the large moth known from its peculiar coloration as the Death's Head Moth, *Acheronita atropos L.*, produces its voice. In vol. 42 of the *Zoolog. Jahrbücher*, Prof. Prell undertakes to settle this question definitely once for all, citing with respect to it some 80 authorities from Réaumur (1736) on, by whom the most various opinions are expressed. Some seek the source of the sound in the abdomen, others in the thorax, and others still in the head. The majority hold the view that the noise is produced by the rubbing together of rough portions of the chitin, *i.e.*, by *stridulation*, while only a few ascribe the tone to the passage of air through the mouth or proboscis. As a general thing, in fact, the utterance of sounds by butterflies has been but little observed, and such cases as are known are almost certainly produced by organs of stridulation and are merely faint chirping noises.

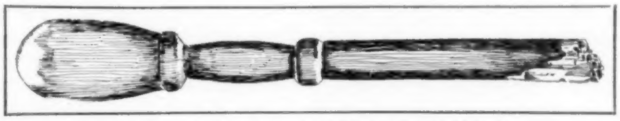


FIG. 11. STICK WITH CARVED EXTREMITY

But in the cry uttered by the Death's Head or hawk moth when disturbed, Prof. Prell distinguishes two notes—one being loud and grating and lasting longer than the other, while the other is shorter in duration and feebler as well as more shrill; this second note commonly follows the other at a brief interval, but may fail entirely when the cry is often repeated. While the cry is audible at a distance of several meters it varies both in strength and in height in different individuals.

It has now been established, by means of direct observation and by means of amputation, that the vocal apparatus is located in the head—even a head which has been decapitated, in fact, is still capable of uttering a cry.

The head of the insect contains a part of the anterior portion of the so-called pharynx, which is enabled by means of very powerful muscles to contract and to expand; this normally operates like a sort of suction and pressure pump for the purpose of taking in food and propelling it farther into the alimentary canal. But unless the mouth is immersed in a liquid it naturally can make use of this arrangement to draw in and expel air in the same manner with a considerable amount of force. The chief peculiarity of the Death's Head is that the *epipharynx*, an appendage of the upper lip found in all insects, is in this instance highly developed. It hangs from the roof of the mouth at the entrance to the pharynx like a sort of palate (*Velum palatinum*), and is capable of closing the mouth, but can be raised and lowered by means of muscles. When the inspired and expired air passes across this elastic plate of chitin—which is not unlike the vocal cords—it is made to vibrate and the rhythmic interruption of the current of air produces the sound described above. It is not unlike the sound produced in snoring (inhaling and exhaling the breath). The proboscis serves merely to intensify the sound.

Prof. Prell concludes therefore that this sound must be regarded as a *genuine vocal utterance.* This is without doubt correct: the sound producing apparatus of this butterfly may be compared to a reed-pipe, similar to the vocal apparatus of most land-dwelling vertebrates, whereas the musical instruments of most insects are constructed after the manner of stringed instruments, set in vibration by friction.

It must be borne in mind, however, that while the sound produced by this moth is actually made by the passage of the air in and out of the mouth, yet this is merely an exceptional use of an organ meant only for the taking in of food—for the mouth is no more an organ of respiration in this insect than in any other.

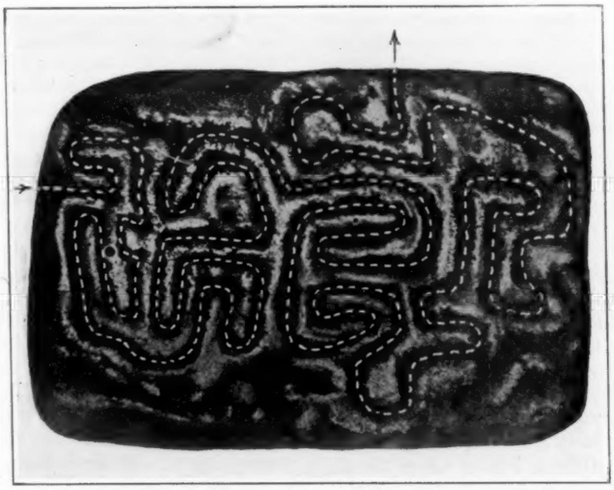


FIG. 12. INCISED MAZE ON ONE SIDE OF AN ARTIFICIALLY WORKED CUBICAL STONE FOUND WITH IDOL OF THE GERM-GOD

The dotted line does not exist on the specimen, but was placed there to enable the reader to trace the meander.

Photograph by T. G. Lemmon.

Most insects possess a breathing apparatus entirely independent of the mouth and consisting of the so-called "stigmata," which are present in great numbers. Hence this must be regarded as a wholly unique exception among articulated animals of the possession of a voice similar to that of land-dwelling vertebrates.

The sound made is a peculiar one, somewhat like the squeak of a mouse; it is superstitiously thought to foretell death or some other calamity.

* Translated from *Kosmos* (Stuttgart).

Are "Harmless" Snakes Really Harmless?

New Studies Which Show the Poisonous Character of the Saliva of All Ophidians

DURING the last few years two well known French scientists, the late Dr. C. Phisalix, and his wife, Madame Marie Phisalix, have made extensive researches concerning the venom of snakes and other animals. They have made various interesting reports concerning this matter to the French Academy. Their conclusions are summed up comprehensively in the latter part of an article upon animal venoms in *Larousse Mensuel Illustré* (Paris) for June, 1920. The most remarkable of their conclusions is that *all* serpents are venomous in spite of the fact that it has hitherto been supposed that only those supplied with poison fangs secreted venom. They find that both the blood and the saliva of all ophidians are more or less venomous, so that when their dentition is complete the saliva at once penetrates the minute wounds made by the teeth; hence these species, which have hitherto been thought quite harmless are really as dangerous as those serpents which are provided with fangs. This venomous action has been thoroughly demonstrated by means of experiments made upon guinea pigs, birds, small rodents, and even upon lizards, with the secretion from the parotid glands of certain Colubers (snakes classed as being non-venomous and including the common grass snake). However, this order of snakes, the aglyphs do not all possess parotid glands: as a matter of fact, Madame Phisalix found only 72 thus provided out of 95 species examined by her.

But recent experiments have clearly proved the toxic action of the blood of Colubers, which is analogous to that of the serpents ordinarily known as venomous, *i.e.*, those possessed of poison fangs and known as proterogryphs (which include the cobras and asps) and solenoglyphs (which include vipers and rattlesnakes). A cubic centimeter of the serum of the smooth skinned Coluber (*Coronella Austriaca*) is capable of killing a frog in one hour and ten minutes, a sparrow in about the same time or five minutes more and the guinea pig in an hour and a half. The symptoms exhibited are stupor, paralysis of the respiratory apparatus and muscular paralysis. This serum does not lose its poisonous properties until it has been kept at a temperature of 60° C. for at least 15 minutes. Mme. Phisalix has also demonstrated the rabicidic properties of the serum of certain aglypha, including the ringed grass snake, the viperine Coluber and the Mauritanian turtle. All of these exhibit definite immunity against the virus of rabies. Furthermore, a contact of no less than 27 hours between the rabic virus and the heated serum of one of these reptiles is required before the mixture again becomes capable of producing rabies in animals inoculated with it—and even then the latter enjoy a temporary immunity.

These researches show, as P. A. Boulenger had already pointed out, that our present classification of serpents is inexact. Mme. Phisalix declares definitely: "The study of the venomous function is too general to be comprised within definite limits. The arrangement of the organs which produce venom, the independent evolution of the inoculating apparatus, the physiology of venoms, and the phenomena of natural immunity exhibited by venomous animals cannot be rationally employed as a basis of classification for ophidians."

Furthermore, it has been discovered that all the lower vertebrates are more or less venomous. Most fishes contain poison in small quantities, and perhaps this is why a too unvaried diet of fish sometimes has ill effects. The researches made by W. Kopaczewski, in particular, have shown the toxic nature of the serum of the murenoid eel (*Muraena* Helena); a dose of 30.5 $cm.^3$ of this is fatal to a guinea pig, 0.4 $cm.^3$ to a rabbit, and 1.5 $cm.^3$ to a dog weighing 5 kg.

Venom is found even more generally among batrachians. Mme. Phisalix has also studied these extensively, and she distinguishes two sorts of glands among them, whose secretions are of different nature, viz., *mucous* venom and *granular* venom.

Mucous Venom.—Mucous venom is that which is secreted by the mucous glands which are distributed over the entire body, being principally found upon the abdomen. It is colorless and venomous and acts upon the nerve centers. It exerts a paralyzing action and when injected into the veins of an animal produces stupor; the respiration suddenly ceases and always before the stopping of the heart. The water obtained merely by washing an ordinary edible green frog (*rana esculenta*) was sufficiently poisonous to kill two adult rabbits.

Granular Venom.—Granular venom is that furnished by the granular glands which are situated solely upon the dorsal surface and upon which depend the parotid glands situated behind the head. They are much larger than the mucous glands. The granular venom found on the back of the terrestrial salamander (*salamandra maculosa*) is a very active poison for cats and dogs. The principal symptoms produced by it are hallucination, terror, salivation, vomiting, and convulsions. The venom of the common toad (*bufo vulgaris*) has a paralytic effect causing a retardation first of the breathing and then of the heart action. Other symptoms vary with the species.

The Odor of Venom.—The poison secreted by batrachians varies greatly in odor. The venoms of the alzte, the pelobate, and the pelodyte smell like garlic; that of the calamite toad smells like powder. On the other hand both the common toad and the land-dwelling salamander produce a poison which possesses the deceptively agreeable fragrance of vanilla. The venom of the crested triton has the appetizing odor of horseradish, while that of the Japanese salamander resembles that of salol.

Venom in Blood and Eggs.—The venom of batrachians passes from their poison glands into their blood and is found even in their eggs. It disappears in the tadpoles and does not again appear until the glands are complete in the adult. There is enough venom in their blood to cause death to various animals when the serum is injected into their veins. But this venom is not present in the muscles, and this is why frog-legs are not only appetizing but nutritious instead of being poisonous.

Self Immunity.—All venomous animals are immune to their own venom. The reason for this is that their blood contains two antagonistic substances, mucous venom and granular venom, which neutralize each other. But the venom of batrachians is poisonous to man only when injected in his veins, which can only be done in the laboratory. In nature these creatures are not only inoffensive and interesting, but also very useful through their destruction of insects.

THE VENOM OF SAURIANS

Lizards.—The helodermian lizard (*heloderma suspectum*) is of peculiar interest in this connection. It is a most curious looking creature and has peculiar anatomical features; it differs greatly from other species of the same order. Its body is covered with conical tubercles like nail heads—whence its name. These are specially abundant upon the head. It has conical teeth on the inner edge of the jaw; these teeth each have two clearly marked longitudinal channels. This creature is sometimes over a yard long and is a horrific looking object. Mme. Phisalix made some curious observations concerning the venom of this animal. The poison affects the respiratory and cardiac action of mammals. On frogs it has the same effect as viper venom. The bite of this lizard is vigorously given and it hangs on to the victim a long time. By means of its channels each tooth makes a double injection in the bite, thus making forty punctures. A strong, active viper, 72 cm. long, died in 52 hours from a heloderma bite. On the other hand,

a heloderma bitten on the cheek by an active viper died in 24 hours, which shows the difference in the physiological action of the two venoms. The bite is sometimes fatal to man from the large quantity of venom injected. Mme. Phisalix herself was bitten on a finger, only one tooth entering the flesh. The bite was followed by severe pain of the entire arm, while the hand swelled and turned purple. This lasted for 3 hours, and it was several days before the hand was normal.

Scorpion Bites.—A scorpion bite in an adult is followed by lively pain at the locality, extending afterward to the whole limb. There is also a cold sweat, vomiting, and reduced temperature. The symptoms disappear in 24 hours if potassium permanganate is injected. In children the bite is more serious and may cause suffocation.

Venom as a Medicine.—The fact that a victim of epilepsy happened to be cured by being bitten by a rattlesnake has caused various investigators to test the medical action of venom. It is found that it greatly relieves epileptic attacks.

CHEMICAL AND BACTERIOLOGICAL TESTS OF EGGS

AN exhaustive investigation of the chemical and bacteriological differences between fresh eggs and ordinary commercial eggs has been made by the Department of Agriculture, and has attracted attention not only in this country but abroad. The term fresh is properly applied to eggs only when they are less than twenty-four hours old and have been kept in a cool and well aired place ever since laid. Other eggs are divided into those which have been taken from a sitting hen and those which have not. The tests of these two classes of eggs yielded the following results:

1. The eggs gathered in July and August contain very few micro-organisms and in many cases no coli bacteria were present whatever.

2. The majority of the tests of eggs of the first class when the shells were clean had comparatively few bacteria and only 8.3 per cent of these possessed more than 1,000,000 germs in one gram by volume.

3. Eggs with dirty shells, or with cracks, or eggs with a yolk which mingled with the albumen contained over 1,000,000 germs per gram by volume, but likewise 16.6 per cent or 18.8 per cent or 20 per cent of them, respectively, were notably freer from coli bacteria than the first group.

4. Eggs having a speck of blood contained comparatively few bacteria; those having a large spot of blood were usually richer in bacteria than those with a small spot: the majority contained fewer than ten coli bacteria per gram of the volume of the egg.

5. The determination of ammonia nitrogen contents showed that the decomposition of the albumen was greater in the different kinds of commercial eggs than in the fresh eggs; but it was less than that of many eggs sold at retail. However, although a cracked or dirty shell indicated danger of infection and consequently decomposition, the tests showed that such eggs have as good keeping quality as those of the first class with clean shells, and that those collected in August and July are the best in this respect.

6. The eggs gathered in July and August and eggs of the first class with cracked or dirty shells can be employed without hesitation both in the household and the bakery.

7. Those eggs which were infected with bacteria included most of those in which the yolk had run into the white and most of those in which the yolk showed a tendency to cling to the shell as also all of those which were either partly or wholly musty or moldy and all of those in which the yolk stuck fast to the shell as likewise those in which the albumen was greenish in color.

8. All the eggs with yolks which exhibited a slight tendency to stick to the shell were less defective from the chemical point of view than the cooking egg of the first class, while the musty eggs, those with intermingled whites and yolks, those with greenish whites, and those with yolks which stuck tightly to the shell, usually exhibit a much greater degree of decomposition. The eggs with black spots contained five times as much ammonia nitrogen as the eggs in the previous groups. None of these eggs is fit for use either in the kitchen or in the bakery, with the exception of those in which the yolks stick but slightly to the shell.

AUTOMATIC PHOTOGRAPHY OF A BUTTERFLY'S WING

SOME very curious biological experiments with respect to the self-recording power inherent in the delicate wing of a butterfly or a moth have been recently made by a German scientist named Gustaf Wolff.

When a butterfly's wing is laid for a considerable length of time upon a photographic plate, in a dark room, a clear image of the wing makes its appearance upon the plate when the latter is developed. In general the images are the positive character, the dark parts of the wing coming out most strongly, while white portions make no impression at all upon the plate Mr. Wolff states that it is the scales of the wing which exert the photographic influence, since when these are removed the wing fails to record itself upon the plate. Even the most delicate "hairs" which are generally dark in tint often make a very strong impression upon a sensitive plate. As everyone who has ever caught a butterly in his hand or clapped them off between his palms, knows the surface scales are very readily removed, since they form an absolutely homogeneous surface covering, they can actually be peeled off like a glove from the hand, if the wing be pressed upon a glass plate covered with moist gelatine and then removed. In making this experiment it is best to employ a dia-positive plate, which is first prepared then dried and again moistened, just before the wing is laid upon it. After the removal of the body of the wing it is found that the layer of scales adhering to the gelatine-covered plate, make exactly the same photographic impression that the entire wing did. The so-called "auto-type" thus obtained resembles a photograph in clearness and delicacy of detail. Brightly colored parts of the wing exert a very slight effect, if any, upon the plate.

Strange to say repetitions of these experiments show that sometimes positive images and sometimes negative ones are produced. In first experiments made with the swallow-tailed butterfly, for example, the black portions of the wing had no effect, while the bright yellow portions blackened the plate. But in later experiments these results were reversed, hence it is evident that there are both positive and negative swallow tails and that this distinction is individual in nature.

The effect exerted by the scales is able to penetrate thin paper and leaves of gelatine, but is unable to pass through celluloid and glass—even the thinnest watch crystals.

WEATHER AND THE OPENING OF COCOONS

THE well-known Swiss scientist, M. A. Pictet, has made an extended series of experiments on the effect of the weather upon the opening of the cocoons of moths and butterflies. The data discovered and published by him are most interesting and obviously of great significance in agriculture, since hundreds of thousands of the farmer's worst enemies spend a portion of their lives in the cocoon phase. It was found that in most varieties of insects, the emergence of the pupa from the cocoon coincides with the fall of the barometer, and that a relative increase of the internal pressure within the cocoon is a necessary factor in the escape of the insect from its prison. When there is an augmentation of the atmospheric pressure during the entire time of this dormant stage of the pupa, or even during the latter half of this period alone, the duration of the dormant stage may be extended from 10 to 20 per cent. Furthermore, when the emergence of the insect is too long retarded, the pupa perishes while still in the cocoon.

A fall of a single millimeter of the mercury in the barometer tube was enough to cause the opening of the sufficiently mature cocoons, while, on the other hand, an increase in the atmospheric pressure was sufficient to postpone the coming forth of such insects for as much as two, three, or even four days until the barometer fell once more.

BREAK-UP OF A HERD OF SEALS AT THE CLOSE OF THE BREEDING SEASON IN THE EARLY FALL

Taking the Census of the Seals

How the U. S. Bureau of Fisheries Keeps Track of the Herds on Our Islands in Bering Sea

EACH year, in the late summer and early fall, a census is taken by the U. S. Bureau of Fisheries of the fur seals on the islands of St. George and St. Paul in the middle of the Bering Sea. This census is necessary as a check upon "blind killing" of the animals which would quickly result in their extinction. Last year's count showed 550,000.

When spring opens in the Far North the sleek and silken seals are to be seen moving toward the rocky, fog-hung shores where they were born. They come back from their annual migration for renewed courtship and battle, love and hate, life and death, after the manner of their kind. After the census is taken and the polar ice comes down they leave once more the Bering Sea. As to where they go for the winter after proceeding through the passes of the Aleutian Island chain, that is a source of mystery that has never been solved. They move southward in a great arc, fattening on candle fish, following a compelling instinct. After putting to sea none of them hauls to land again until the following summer.

This great seal herd has grown from a few thousands of not so long ago to more than half a million in a few years under a pledge with England, Japan and Russia, whereby the United States must share fur profits with these countries in return for prohibited open sea sealing.

The make up of the herd ranges from breeding cows, surplus and idle bulls to males from one to six years, yearling cows and pups. While in 1912 there were only 81,984 breeding cows there were in the 1919 census 142,015. The breeding bulls during the same number of years have increased from 1,358 to 5,344. The pups have increased in the same amount as the breeding cows, while the younger specimens now number many thousand more than they did eight years ago.

From time to time calls are made upon the United States Bureau of Fisheries by scientific institutions for specimens of the Alaska fur seal for exhibition or other purposes. There is no authority by law whereby animals may be killed to supply this demand. However, a few cows and bulls and a considerable number of pups are found dead on the rookeries each year and these afford a means of fulfilling such requirements. The existing law requires that all seal skins from the Pribilof Islands shall be sold and the proceeds turned into the treasury. In arriving at a price to be fixed for such specimens from dead animals, consideration has been taken of the fact that many of them are worthless commercially and for others it would be difficult to obtain an equitable appraisement. Therefore the sum of one dollar each was fixed as the value of the pups and five dollars each for the older animals. Institutions securing such specimens pay all charges for labor and transportation.

The Pribilof Islands where the seal breeds are of volcanic origin. The nearest land is Unalaska Island, 214 miles to the southward, and the next nearest is St. Matthew Island, 220 miles to the north. The distance of the islands from the mainland is a little more than 300 miles. The group comprises five islands, St. Paul and St. George, lying about forty miles apart, being the principal ones. On the shores of the two larger islands the fur seals have most of their breeding rookeries and hauling grounds. The rookeries are usually separated from each other by stretches of sand or abrupt cliffs, or in some cases by sections which have been abandoned. The breeding masses usually extend back from the water's edge but a short distance.

In 1868 and 1869 about 242,000 and 87,000 seals, respectively, were taken on the Pribilof Islands by various independent parties. In 1870 a law was enacted providing for the leasing of the sealing privilege for a term of tweny years, at an annual rental of not less than $50,000 and a tax of two dollars on each skin taken. Under the terms of this contract, a lease was entered into by the Government with the Alaska Commercial Company, a corporation including some of the American sealers who had operated on the islands in 1868 and 1869. This company agreed to pay an annual rental of $55,000 and a tax of two dollars sixty-two and one-half cents on each skin taken. Certain concessions were made to the natives and the right to make further rules and regulations governing the industry was vested in the Secretary of the Treasury. Under the lease the company took a quota of about 100,000 seals annually until 1889. The total number of skins taken on the islands during the twenty-year period was 1,977,377 and the revenue that these skins brought in

to the Government amounted to a total of $6,020,152.

New leases then jumped the annual rental to $60,000 per annum while the tax on each skin taken was raised to nine dollars and sixty-two cents. More liberal provisions were made for the care of the natives, and the number of seals to be killed annually was placed at the discretion of the Secretary of the Treasury. For the first year the number was 60,000. The leasing system was discontinued in 1910.

Recognizing that the brutal and wasteful killing at sea was greatly against the interests of the herd, the United States sought to establish jurisdiction in Bering Sea as a closed sea and seized a number of Canadian sealing vessels found operating there. This led to a controversy with Great Britain, which resulted in a treaty concluded February 29, 1892, consigning the whole matter to the deliberation of a tribunal of arbitration which met at Paris in the summer of 1893. Pending this treaty and the result of the deliberations of the tribunal, an agreement between the United States and Great Britain was entered into June, 1891, by which the latter country prohibited British subjects from sealing in the eastern part of Bering Sea, and the United States prohibited all killing whatever by its citizens excepting that of 7,500 seals annually for the food of the natives of the Pribilofs.

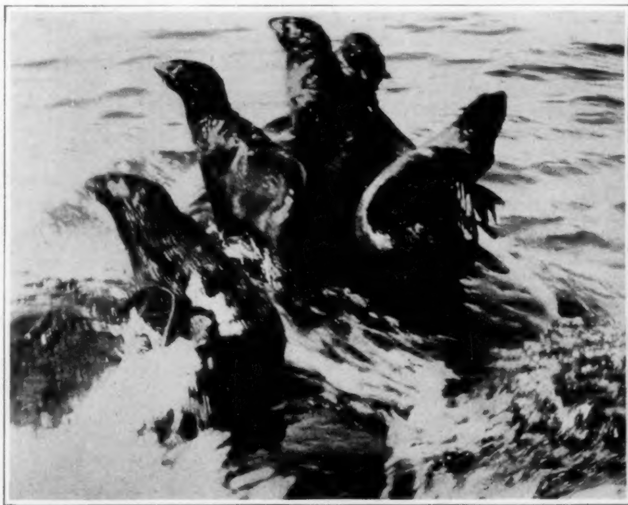
OLD BULL SEAL AWAITING THE ARRIVAL OF THE COWS IN THE EARLY SPRING

Among the results of the work of the Paris tribunal was a set of regulations closing to pelagic sealing a zone of 60 miles in radius about the Pribilof Islands, and prohibiting it entirely between May 1st and July 1st. These regulations went into effect in the summer of 1894, and of course affected only the citizens of the United States and Great Britain. They were subject to re-examination at intervals of five years. The experience of a single season showed that the result was ineffective, since the catch from pelagic sealing increased, and the seal herd continued to decline, and in 1896 this country accepted the proposal of Great Britain that the two countries institute independent scientific investigations of the entire matter at the close of the five-year trial period. These investigations were made in 1896 and 1897, and a voluminous report on the work of the American investigators was published in 1898. In the meantime, on December 29, 1897, Congress had enacted a law forbidding American citizens from engaging in pelagic sealing at any time or place.

In 1911 the United States, Great Britain, Russia and Japan entered into a treaty which abolished sealing on the high seas for a period of fifteen years. By its provisions the United States and Russia, as owners and guardians of the seal herds, agreed to pay Great Britain and Japan for the relinquishment of their interest in pelagic sealing a percentage of fifteen per cent to each of the product of the land sealing to be conducted by each of the two nations. In a like manner Japan agreed to pay to the United States, Great Britain and Russia, respectively, ten per cent from the land catch from the small but growing herd under her jurisdiction.

On August 4, 1912, the Congress of the United States passed a law prohibiting all killing of fur seals on the Pribilof Islands for a period of five years except the number needed as food for the natives, and providing for a breeding reserve of not less than 5,000 three-year-old males annually during the life of the treaty suspending pelagic sealing. Under the operation of this law only the skins of seals taken for food have been handled.

The work in connection with the Pribilof Islands expanded greatly in 1918 with the resumption of commercial killing of seals. A number of natives were secured from Unalaska to aid in the work, and temporary assistants were employed for sealing operations and general construction and repair work on the islands. Necessary transportation of supplies and products was furnished by the Bureau of Fisheries steamer department. Fur-seal skins and fox skins were taken and preserved as usual. A by-products plant was erected on St. Paul Island for the conversion of seal carcasses into oil and



COW SEALS JUST ARRIVED AT THE BREEDING GROUNDS

A GROUP OF FUR SEAL PUPS WAITING TO BE COUNTED

THE CENSUS TAKERS COUNTING THE MEMBERS OF A HERD ON ST. PAUL ISLAND

fertilizer. Cold-storage facilities were planned, and the general administration of the natives' affairs was carried on.

It is to make sure that no illegal killing is going on that every year the Government takes a census of the seals, and while it is impossible to make a full census without some proportion of estimate, at the same time the cessation of pelagic sealing has provided opportunity for actual counts of the breeding elements of the heard, the old males and females and the young of the year. With elements positively known and killing records complete for several years, the non-breeding seals can be estimated by making use of the number supposed to die from natural causes. At present the rate of mortality must be inferred, and herein lies the only element of uncertainty in the census.

The classes of seals actually counted are the breeding bulls in active service, the idle bulls on the breeding ground, and the young pups of the season. Actual counts are also made of the half bulls and bachelors, but give only partial results of value chiefly as a check upon the estimates. The classes estimated are the yearlings and the two-year-olds of both sexes, and the bachelors from three to five years of age. The number of breeding cows is directly inferred from the number of pups.

The method of counting is simple. The rookeries are mostly extended along the shore in linear formation frequently beneath low cliffs from which the observer can look over them with ease. In the present condition of the herd the number of bulls in tier formation between the shore and the back of the rookery does not often exceed five, and marked rocks and natural prominences are sufficient for all necessary subdivision of rookery space into areas for successive counting. The large relative size of the bull makes him conspicuous even at a considerable distance, and except when fully recumbent in a heavily massed area, he cannot possibly be overlooked.

In order to prevent mistakes and to make general preliminary observations, numerous counts of various classes of seals are made before the height of the season. In this way counts are made at least once for every rookery on St. Paul Island and some rookeries are counted from three to six times. In addition, weekly counts are made of all the rookeries on St. George Island in late June and early July. Therefore, when the height of the season arrives in September those engaged in the count are familiar with the peculiarities of each rookery and all are agreed as to the method to be employed.

Counting bachelors may be compared to counting a swarm of bees, part of which is in the hive and the remainder out gathering honey. The full number cannot be determined with accuracy although various devices are available as the basis of estimates. Those on land at a given time may be closely approximated by a process of combined counting and estimating. After some experience, results may be obtained in this way which, as minimum figures, are wholly reliable. It is often possible to find a herd of bachelors practically all of which are lying asleep, so an observer in an elevated position with a good field glass can count them with considerable accuracy. Conditions for counting in this manner are particularly favorable on St. George Island. A large herd of bachelors in which all or many individuals are in motion can only be estimated by counting those on a certain space and correlating the number obtained with the total space occupied. At times the bachelors on a given hauling ground may be driven back a short distance and divided into small pods which are successively counted as they form in an irregular line to return to the sea. Taking all data of this sort into consideration, the observer spending an entire season on the islands is in no doubt, as to the approximate number of bachelors usually found on each hauling ground.

Since 1897, when it was discovered that the number of pups greatly exceeds the number of cows on land at any one time, the importance of an enumeration of the pups has been apparent. Unlike the other classes of seals, all the pups for a time are on land at once, and the only obstacle in the way of exact knowledge of their number is that of actual enumeration. Until the abolition of pelagic sealing, however, a complete count of pups was not attempted, since it involved driving the cows into the sea and exposing them to the sealing fleet. Since 1912 with this danger past, complete counts of pups has been made. They not only give a measure of the new generation in the herd, but also furnish an accurate index of the number of breeding cows, since each cow gives birth annually to one pup.

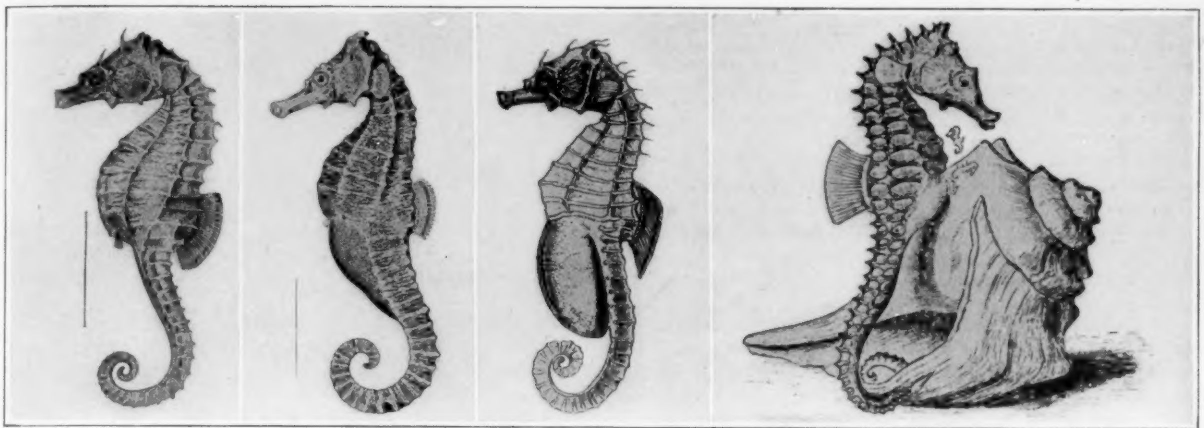
THE REMOVAL OF INK STAINS

BY DR. GERHARDT

THE problem was to remove some ink stains from a cotton cover. The ink in question was an iron gallate ink. The spots withstood the action of warm oxalic acid, also a mixture of oxalic acid, citric acid and common table salt, as well as the simultaneous action of powdered tin and oxalic acid. After this treatment the spots became light blue in color, but could not be removed entirely.

The spots yielded, however, surprisingly easily to treatment with potassium permanganate ($KHnO_4$), mention of which fact could not be found anywhere in the literature. Several tests were made with this substance and all were so successful that it is recommended as a sure eradicator of ink stains on cotton. The method of procedure is somewhat as follows: The stains are first painted with a dilute permanganate solution (for example, about one ounce of the permanganate in a glass full of water). The solution was allowed to act a few minutes and then was washed away with water. The brown coloration was removed with sodium bisulphate (the photographer's "hypo") and citric acid, and finally the cloth was thoroughly rinsed out again with water.

When the cloth is dyed a test must be made on a small spot to see if this treatment does not remove the dye as well. It is well to paint the stain with an oil ring so that the treatment is limited within a very small range and so that the unstained cloth is not subjected to the action of the reagents.—*Zeits. angew. Chem.*, 1920 I. 32.



HOW THE SEAHORSE CARRIES ITS YOUNG IN A KANGAROO-LIKE POUCH
1. A female seahorse (*Hippocampus Hudsonius*). 2. Male (*Hippocampus alterimus*) with normal pouch. 3. Male (*Hippocampus Hudsonius*) with dilated pouch. 4. Male discharging young from pouch (after Lockwood)

Fishes with Prehensile Tails

The Odd Little Seahorse That Carries Its Young in a Pouch

THE convenience of a prehensile tail for animals which make their airy way swaying from bough to bough in the dense growth of tropic jungles is obvious enough, and the delight with which young and old regard this graceful exercise indulged in by monkeys, either free or captive, is possibly due in part to some deep atavistic consciousness of a time when man, or his immediate progenitors, enjoyed a similar advantage. But what need have the denizens of the deep of such an implement? None at all obviously so far as the fishes who dwell in really deep waters are concerned, but there are certain curious little fishes, the seahorses and their cousins, the pipe-fishes, which live in shallow waters near shore and commonly haunt the miniature jungles of eel grass and seaweed, who find such a power of grasping the surrounding vegetation extremely useful, and who have accordingly developed this prehensile action in a remarkable degree.

This power is all the more useful to them because their powers of locomotion are very poor. The swift moving crustaceans, worms, etc., on which they feed could easily escape them did they depend merely on the chase, but this power of anchoring themselves to a bit of eel grass enables them to lie in ambush and snatch their prey as it darts past. They are further aided by the strong power of suction they possess through their long snouts which resemble pipes or muzzles as the case may be.

The most curious feature exhibited by these fishes, however, is the pouch in which the young are carried, much as the young of a kangaroo are carried in the mother's pouch. Strange to say, however, in the seahorses and in those of the pipe fishes which possess this feature, it is the male parent who thus carries his offspring about with him. As our pictures show the pouch before the eggs are laid in it by the mother is flat and inconspicuous, whereas later it is distended

GENERAL FEATURES AND HABITS

While the seahorses or Hippocampids vary in form to some extent there are typical features common to all of them. Thus all have very rigid compressed bodies, hemmed in by plates, which are so connected that the animal is incapable of bending sidewise to any great extent. All of them have long curving four-sided tails—this tail is more or less prehensile, in typical forms very highly so. This, indeed, is one of the most characteristic features of the fish, since, as we have said, it alone and some of its cousins, the pipe fishes, are provided with these so-called grasping tails. The tail is employed to anchor the fish to the seaweeds or eel grass which is its favorite resort and where it finds not only shelter but its favorite food in the form of the small spiral worms and the tiny crustaceans upon which it lives. While the seahorse generally keeps an erect position, both when swimming and while at rest, it sometimes extends the body at an angle or even in a downward direction from the spot to which it is clinging; occasionally the tail is even wrapped in a double coil around the plant.

Because of the almost inflexible coat of mail in which its body is enclosed, the seahorse cannot move as ordinary fishes do, by bending the body from side to side, but this difficulty of movement is largely compensated for, not only by the strength and flexibility of the tail but by the fact that the air bladder is unusually large and is always distended by an amount of air which so exactly corresponds with the amount required by the specific gravity of the body as to form an extremely sensitive hydrostatic apparatus. A proof of this is furnished by the statement of Theodore Gill that if a single bubble of air, no larger than the head of a very small pin, be lost through a puncture of the air bladder, the fish immediately loses its balance and falls to the bottom, upon which it is forced to crawl about until the air bladder is healed and once more air tight; this air bladder is really filled by a sort of "gas" which is secreted by its inner membrane.

VARIOUS SPECIES OF THE SEAHORSE

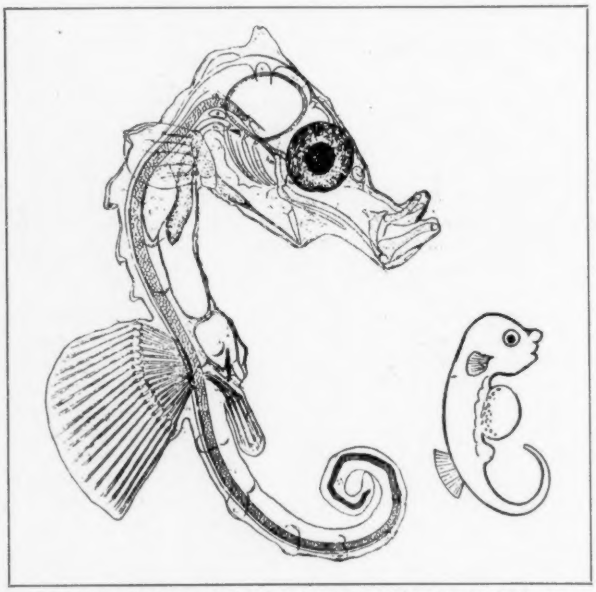
There are between 30 and 40 species of *Hippocampus*, the distinctions between them being based chiefly on the number and the length of the rays composing the dorsal fin, the number of rings encircling the body, the comparative lengths of the body and tail behind the anus, the depth of the body or distance across from the dorsal ridge to the ventral, and the relative length of the head and snout in front of the eyes. These are supplemented by the comparative development of the tubercles or spines, of the coronet at the crown of the head or nape, of the filaments with which the body may be covered, and the color.

The common eastern American seahorse (*Hippocampus hudsonius*) has a long dorsal with about 19 rays, about 45 (10 + 32-35) rings, the tail longer than head and trunk combined, the snout short but appreciably longer than rest of head (1.3—1.4:1), and the depth of the body approximately equals the length of the head. The coronet is little developed, the tubercles and spines weak, and the filaments rather few,

short, and mostly simple. The color is dusky and spotless (but blotched) and the dorsal has a submarginal dark band. This species was up to some two years ago very common in the vicinity of New York harbor, but the bitter winter then experienced killed it off.

The sea-wrack seahorse (*Hippocampus zosteræ*) of Florida contrasts with the common species of the north in most of its characters. It has a short dorsal (covering only 3 rings) with about 12 rays, about 41 (11 + 30) rings, the tail rather shorter than the rest of the body, the snout extremely short and not more than half the rest of the head, and the depth of the body great and almost equal to length from snout to margin of pectoral fins. The coronet is high, the spines are well developed, and the filaments moderate and often branched. The color is olive green, more or less mottled, and the dorsal has no distinct submarginal head. It is, according to Jordan and Evermann, "the smallest known species of seahorse, abundant in shallow water in the lagoons, always found clinging by its tail to the sea-wrack (*Zostera marina*)."

While the more common species of *Hippocampus* are certainly singular enough in aspect, certain ones found in tropical seas are still more exaggerated in form. The oldest looking of all are the *Phyllopteryx foliatus* and the *Phycodurus eques*;



YOUNG SEAHORSE VIEWED AS A TRANSPARENT OBJECT
At right, very young seahorse with yelk sac

the former exhibits a really marvelous simulation of a bit of the seaweed among which it makes its habitat. This strange foliated structure is due to the enormous development, especially around the tail, of certain cutaneous appendages which are in most species merely tags of skin.

Seahorses have a very curious method of feeding. Because of their slow motion they would have great difficulty in catching the little crustaceans, such as sand fleas, opossum shrimps, upon which they mainly feed (though they are willing to eat mosquito larvæ and other water insects) except for their power of exerting a strong suction through their long snouts, but even so the prey must be at rest, either on a plant or at the bottom.

HOW THE YOUNG ARE CARRIED

Strangest of all the habits of the seahorse is, as we have said in the introduction to this article, its custom of incubating the young in a pouch, after the manner of kangaroos and opossums, but this pouch belongs not to the mother fish but to the father. The mating season, in these waters, at any rate, is in early summer, and at this time the female deposits her eggs in the pouch of the male which, as our picture shows, is situated just below the "cuirass" of the body at the beginning of the tail. This pouch is especially adapted, not only for holding the eggs until they are hatched but, also, for nourishing the newly hatched babies. The pouch becomes thickened and vascular at this time of the year and is lined with a mucous membrane which secretes "an aeriform fluid." According to Lockwood, when ready to receive the spawn, the wall of the pouch is not less than three lines thick and is well stored inside with fat. When the young fry is expelled after being sufficiently developed, on the other hand, the pouch has become merely a thin loose membrane hardly half a line in thickness.

The young not only live in the father's pouch for some time after their birth, but are accustomed when old enough to make private expeditions from it in search of food, returning like fledglings to a nest; but when the patient parent begins to find them a burden he does not hesitate to evict them from their happy home, either by curling his tail underneath the pouch and exerting a strong upward pressure which forces the young out, or else by literally scraping them out against some convenient object, such as the winkle shell shown in our illustration.

This picture was drawn by Lockwood and the operation it represents, which, by the way, is by no means actual "labor" in the specific sense of that word, but is merely mechanical, is thus described by him: "With its abdomen turned toward the shell, its tail attached to the under part of it, the body erected to its full height, the animal, by a contractile exertion of the proper muscles, would draw itself downward and against the shell, thus rubbing the pouch upward, and in this simple yet effective way, expelled the fry at the opening on top of the sack." This is not a continuous operation, but each effort was "followed by a few minutes of rest," and the extrusion of the young "lasted for nearly six hours, from three to six individuals being set free at a time." The young are then fully developed.

PROTECTIVE COLORING

While the dense growth of eel grass or seaweed, which is the common habitat of these fish, affords a refuge for enemies as well as an excellent ambush not to say a happy hunting ground, the fishes also present a very interesting protective coloring which varies from place to place according to the varying colors found in the environment. Thus among the brilliant rocks and vegetation of the southern Mediterranean they disport themselves in all the colors of the rainbow. These very fish however, when removed to the more sober surroundings of northern waters quickly assume the soft brownish and greenish hues of the surrounding vegetation.

When the fish lets go its hold, described above, upon the supporting object, it moves slowly away still in a vertical position, with its tail curved inward and its dorsal fin vibrating rapidly, so as to remind one of the propeller of a boat. The pectoral fins vibrate in unison and in both cases the rapidity of the undulatory movement is very remarkable.

Mechanism of Sound Production.—"The sharp, little, snapping noise" made by these fishes is very characteristic. It is produced by the abrupt opening and closing of the lower jaw and the muscular motion involved in this was found by Dufossé to consist of a series of movements so extremely slight and so rapid as to be invisible, though they can be perceived by the sense of touch, as a sort of vibration or quivering motion. Both sexes produce these sounds and they are most intense in the breeding season, and probably assist in the matter of courtship.

It was Lockwood who first observed the phenomenon. While drawing certain specimens placed in separate dishes he heard the staccato noises referred to and found them to be coming from one of the glass dishes. Almost immediately the sounds or signals were answered from the other vessel, and doubtless the little creatures were comforted and reassured amidst their strange and alarming surroundings by this conversation.

Fish that Bear Their Young Alive

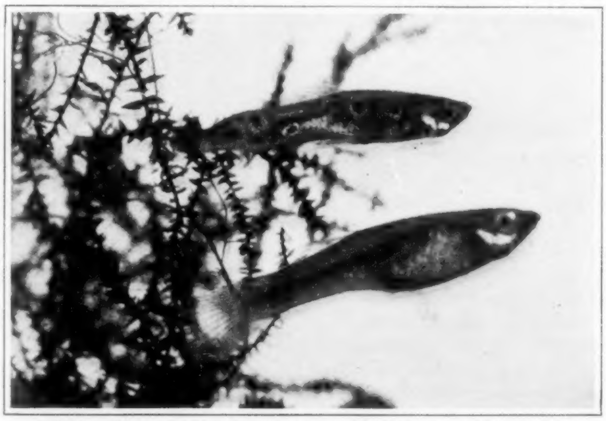
Curious Habits of Kilifishes, Cave-Fishes, Sharks, Rays, Etc.

THE habit of laying eggs is so nearly universal among fishes that probably most people will be considerably surprised to learn that certain species of various families of them actually bear their young alive. Among these is the large family of kilifishes, or *Cyprinodontidae*, sometimes known as toothed carps.

About one hundred and forty species are now known, from the streams and brackish lagoons of the eastern United States, tropical and South America, Africa and Asia. Few are found in Europe, and few in the north Pacific region, and none much north of the latitude of Boston. The majority frequent brackish lagoons, lowland swamps, and mouths of rivers, but the strictly fresh water species often abound in the clear fountain-heads of streams. Some African species live in hot springs.

The species are all of small size, some of them (*Heterandria*) being the smallest known vertebrates. The largest species (*Anableps, Fundulus*) seldom reach the length of a foot. In most species the sexes are dissimilar, and in several genera the anal fin of the male fish is modified into an intromittent organ, whereby the ova are fertilized before extrusion. In such species the young are developed in a sort of uterus and are born at a comparatively advanced stage of development. When born they closely resemble the adult fish. All of them are very tenacious of life.

That the bearing of the young alive by certain fish is not significant of a higher state of evolution, as the layman might



GIRARDINUS VECTICULATUS (*GUPPYI*)—A VIVIPAROUS FISH COMMONLY CALLED THE TROPICAL FISH

naturally suppose, is proved by the fact that it occurs in many species of the sharks and their cousins the rays, though these are among the earliest, i.e., the most ancient fishes that we know. This habit of procreation has been developed among certain species of widely various families according to local conditions in order to give the young fry a better chance for survival than they might otherwise have—it is literally a case of "fewer babies but better ones." In some sharks there is a structure analogous to the placenta found in mammals, but it is not of the same character or origin. There is actual union in the case of viviparous fishes and there is accordingly a modification in most cases of some organ, as was remarked above, so as to fit it for effecting the transfer of the fecundatial cells. This is the purpose of the sword-shaped anal fin in many top-minnows, while in the Elasmobranchs large cartilaginous organs known as claspers are developed from the ventral fins.

Among the rockfishes and the rosefishes the young fry are exceedingly small when first born, while in the surf-fishes they are large and few in number, as is also the case in the sharks.

An interesting example of a viviparous fish in which the young are minute in size and produced in large numbers is the blennie. A writer in the Royal Natural History thus describes them: "The fry, which at birth are perfectly transparent, and form beautiful objects for the microscope, are so fully developed as to be able at once to swim freely on leaving the body of the female parent. Before their birth the female bcomes so distended, that at the slightest pressure the young are extruded; these frequently being from two to three hundred in number, and always making their appearance in the world head first. The general color of the fish is pale-brown, with the dorsal fin and upper parts mottled and barred with darker brown.

Most of the viviparous species feed upon mud; the rest upon insects and other small organism. They are generally surface fishes and swim slowly about with their eyes half in and half out of the water. The most curious of all these is the genus *Anableps* which lives in the streams of the American tropics. This is sometimes called the four-eyed fish, for the reason that its large prominent eyes which actually resemble marbles on top of the head are divided horizontally into two parts, the lower half being fitted for water vision and the upper half for air vision.

Here, as so often, we find in nature a preliminary use of one of man's boasted inventions, the bifocal spectacles. These fishes are the largest of the *Cyprinodontidae*, sometimes being a foot or more in length.

Another member of the family, however, a pretty little fish, living in southern lowlands, is the smallest of all known fishes, being rarely more than half an inch long. This tiny creature bears the formidable name of *Heterandrie formosa*. Other genera include the *Jordanella* which look somewhat like young sun-fish and which are found in the lakes and everglades of Florida, the *Cyprinodon*, a small, chubby, carnivorous fish found on the shores of America and southern Europe, the *Fundulus* which is widely distributed in both fresh water and salt, and the *Ganbusia*, one species of which abounds in the swamps and brooks of southern lowlands. In this species the males are not only smaller than the females but far less numerous.

Cave Fishes.—Closely allied to the family just described are the remarkable cave fishes or *Amblyopsidae*. In these the young fish are only one-fourth of an inch long. Only five species are known, the largest of which is only five inches long. They live in the streams which run through the caves which abound in Kentucky, Tennessee, Alabama, Illinois and Indiana, and a single species is found in the ditches of the rice fields of South Carolina.

Two of the species inhabit only the depths of the subterranean rivers. In these the eyes consist of a mere useless rudiment hidden beneath the skin. As a compensation for this blindness, however, the head and body are covered with numerous rows of highly sensitive papillae which form a very delicate organ of touch. The body is translucent and colorless.

In the genus *Chologaster*, the celebrated fish of the Dismal Swamp, on the other hand, the eyes are well developed and the body decked with color as is usual in fishes. Directly descended from the *Cholgaster* are the blind fish found in the limestone caves which abound from Southern Indiana to Northern Alabama. Only the Mammoth Cave blind fish *Amblyopsis spelocus* is common in collections, the others being rather rare. In these fishes the vent is peculiarly situated instead of behind the ventral fin as usual.

Professor Cope makes the following interesting statement about them: "If these *Amblyopsis* be not alarmed they come to the surface to feed and swim about like white aquatic ghosts. They are then easily taken by the hand or net if perfect silence be preserved, for they are unconscious of the presence of an enemy except through the sense of hearing. The sense is, however, evidently very acute, for at any noise they turn suddenly downward and hide beneath stones, etc., at the bottom. They must take much of their food near the surface as the life of the depth is apparently very sparse. This habit is rendered easy by the structure of the fish, for the mouth is directed upward and the head is very flat above, thus allowing the mouth to be at the surface."

DEGENERATION OF THE EYE IN CAVE FISHES

The gradual degeneration in the eye of these cave fishes is a very instructive phenomenon. It has been studied in close detail by Dr. Carl H. Eigenmann. He divides the history of the eye of *Amblyopsis spelœus* into four periods: The first extends from the appearance of the eye until the embryo is 4.5 mm. long, and there is a normal palingenic development except that the cell division is retarded and there is very little growth. The second period lasts until the fish is 10 mm. long, and during this time the eye continues to develop till it reaches the highest stage attained by the *Amblyopsis* eye. The third period continues until the fish is from 80 to 100 mm. long. During this time various changes, some progressive, some of them distinctly degenerative, take place. The fourth and final period continues until death and is characterized by degenerative processes alone.

While the eye of the *Amblyopsis* appears at the same stage of growth as in normal fishes, it grows but little after making its appearance. The lens appears at the normal time and in the normal way, but its cells never divide and always remain embryonic in character. It is the lens which first exhibits signs of degeneration and it disappears entirely before the fish is 10 mm. long. The optic nerve exhibits itself just before the fish attains a length of 5 mm. It does not increase in size as the fish grows and it disappears in old age. The scleral cartilages appear when the fish is 10 mm. long and grow very slowly, possibly till old age.

Dr. Eigenmann says: "It is evident that the causes controlling the development of the eye are hereditarily established in the egg by an accumulation of such degenerative changes as are still perceptible in the eye of the adult."

Two theories exist as to the cause of the loss of eyesight, according to Dr. Jordan, namely, the Lamarckian theory of the inheritance in the species of the results of disuse in the individual and the Weissmann doctrine that the loss of sight results from cessation or reversal of selection. Dr. Eigenmann inclines to the former belief but Dr. Jordan is uninfluenced by his views.

We may close this account by a quotation from notes made by Miss Ruth Hoppin, of a fish taken from a well in Jaspar County, Missouri. This was a blind fish of the species *Troglichthys rosae*.

"He seems perfectly healthy and as lively as when first taken from the well. I gave him considerable water, changed once a day, and kept him in an uninhabited place subject to as few changes of temperature as possible. If not capable of long fasts he must live on small organisms my eye cannot discern. He is hardly ever still, but moves about the sides of the vessel constantly, down and up, as if needing the air. He never swims through the body of the water away from the sides unless disturbed. Passing the finger over the sides of the vessel under water, I find it slippery. I am careful not to disturb this slimy coating when the water is changed.

"Numerous tests convince me that it is through the sense of touch and not hearing that he is disturbed. I may scream or strike metal bodies together over him as near as possible, yet he seems to take no notice. If I strike the vessel so that the water is set in motion he darts away from that side through the mass of water instead of around in his usual way. If I stir the water or touch the fish, no matter how lightly, his actions are the same."

USING DEVIL FISH FOR GRAPPLING IRONS*

By Dr. C. Ishikawa

One of the ways in which Japanese fishers catch the devil fish, *polypus vulgaris Lam* (*octopus octopodia*, L.), is as follows:

At the end of a stout bamboo rod two strong hooks are fastened while above them is the bait upon a small hook. At the other end of the rod and upon the oposite side a sinker is attached. The whole apparatus is hung upon a very long line and lowered to the bottom of the sea so as to lie there in a slanting position; it is then jiggled up and down gently which causes the bait to move with an appearance of life. As soon as the fisherman sees a polyp catch hold of the bait, he seeks to jerk the line in such a manner as to catch the hook into the flesh of the animal and draw it to the surface.

This apparatus is used in different parts of Japan, being the same in general principle but varying somewhat in size and manner of construction. The apparatus used in the neighbodhood of Hasihama in Ijo, upon the Island of Sikoku, consists of a piece of bamboo about 13 cm. in length, ½ cm. in width, and 1 cm. in thickness. The upper half of the piece of bamboo widens out into a spoon-like shape measuring 26 mm. at its greatest width. The smooth, hard outer side of the piece of bamboo is directed to the front, and the inner side to the rear. At the point of the narrow part upon the outer side (which lies upward when the apparatus is resting on the bottom of the sea) two strong hooks are fastened with a rope; the points of the hooks are directed toward the broad portion of the piece of bamboo. One end of the rope is left free and used for attaching the bait. In the middle of the piece of bamboo and upon the same side a small hook is attached with its point extending in the opposite direction; this hook is used for holding the bait. A small triangular iron sinker, about 4½ cm. long and 3 cm. wide at the bottom, is loosely attached to the broad part of the bamboo by means of a flexible piece of wire. The piece of bamboo ends in a knob at this point to facilitate the attachment to the rope.

Most of the octopus catchers in this neighborhood live upon the little Island Kurusima . . . Just here there is a very strong current in the sea which has long been regarded by the fishermen as very dangerous. About fifty fishers dwell upon this charming little island and more than half of them are engaged in polyp fishing. These animals are found here in such abundance that a fisherman often is able to catch from fifty to seventy-five kilograms in a single day. The depth of this passage averages about 50 meters; the bottom is mostly covered with small blocks of stone under which the polyps take refuge.

As we have said, this passage has long been perilous to ships on account of the strength of the current and many romantic tales are told of the accidents hereabouts. In former times the vicinity was notorious for the sea pirates who made their headquarters here, since it was an excellent place to lie in wait for passing ships. Among the oft told tales still current is the following:

More than three hundred years ago the famous conqueror of Korea, Hideyosi Toyotomi, had reduced the entire realm of Japan to a state of peace. One day he ordered his vassal, Yurakusai Ota, to make a collection of rare pieces of porcelain from various quarters of the kingdom for use in the ceremonial tea drinkings, which at that time were very popular among the upper classes. This order was passed on to another man, Uyeda, who promptly set forth for Kyusyu to fetch certain rare specimens. Upon his return journey a violent storm burst forth as he neared Hasihama and after a perilous struggle the ship laid to in a small bay. Uyeda went

*Translated from *Kosmos* (Berlin) for the *Scientific American Monthly*.

ashore and sought refuge in a farmhouse to wait until the storm had passed. While he rested there the captain of the ship happened to get news of the death of the mighty ruler who had given the commission for the collection of the china (1598). The captain, who was none too honest, made use of the opportunity to steal the valuable specimens of the collection and take French leave, first taking the precaution to sink the ship. When the unfortunate Uyeda found his ship and his china at the bottom of the sea, he ceremoniously committed harikari. The sympathetic villagers buried him and erected a small temple above his bones to keep him in remembrance. As years passed by the adventure of the porcelain ship gradually became merely a dim legend. But one day the fisherman Kujuro made an astonishing catch. From a depth of thirty fathoms he brought up a polyp which clutched tightly a rarely beautiful piece of porcelain. This happened in June, 1828.

The fisherman remembered the ancient story about the shipwrecked cargo of porcelain and found upon inquiry that the dish he had thus luckily retrieved came from the celebrated city of Karatsu in Kyusyu. He kept his lucky find a secret but at once began recovering choice pieces of porcelain by

A JAPANESE METHOD OF CATCHING DEVIL FISH

means of living polyps. For this purpose he knotted together three strong ropes, each about 36 cm. in length at the same point. He then fastened a living polyp of moderate size to each of two of these ropes, tying the rope firmly about one arm of the animal, the sinker being attached to the third rope; finally a long rope was tied about the place where the other three were knotted together. This apparatus was let down until the living polyp touched ground. As soon as this happened the creature naturally began to crawl away and to assist itself in this effort, it laid hold of rocks and other objects on the bottom of the sea. It was possible to tell when it had attached itself to such an object by the pull upon the rope. Thereupon the rope was quickly drawn in, the animal meanwhile clinging desperately to whatever it had laid hold of, whether this was a stone or a choice piece of porcelain.

In this manner Kujuro succeeded in obtaining a great many valuable pieces of old china which brought a large price in the market. This thrifty enterprise was continued by his sons and gradually this secret hoard of beautiful porcelain received the name of "Karatsu-Iso," *i.e.*, Karatsu Beach porcelain. . . .

Naturally this porcelain is not in very good condition. The salt water has somewhat corroded the surface so as to roughen it. However, this only enhances its value in the eyes of the devotees of the "tea ceremony." Many charming pieces, however, are in perfect condition, even as regards the drawings and paintings with which they are adorned. Some of them have gained in interest if not in beauty by the sea creatures which have clung to them, such as rock-boring mussels and tube-building worms. One particularly fine piece is a beautifully lacquered sword sheath. The blade itself has entirely disappeared under the action of the salt water, but the lacquer is in a marvelous state of preservation, not showing the slightest abrasion after the lapse of 300 years. Since this curious art of porcelain fishing has now been practised for more than twenty-five years, the pieces are becoming rarer and rarer, so that at the present they are seldom brought up.

THE SELECTION OF FOOD PLANTS BY INSECTS

IN the *American Naturalist* for July-August, 1920, Dr. Charles T. Brues of the Bussey Institution of Harvard University gives an account of his study of the selection of food plants by insects, with special reference to Lepidoptera larvæ. Dr. Brues finds that the Lepidopterous insects show a very fixed instinct to select definite plants for larval food and that many are extremely precise in this respect, although some are less so, and others are quite catholic in their tastes. Furthermore there is much to show the existence of a so-called "botanical instinct" in species, genera and even families, whereby evidently related plants and these only serve as food. A few species have departed from the general habit so far that they have become carnivorous.

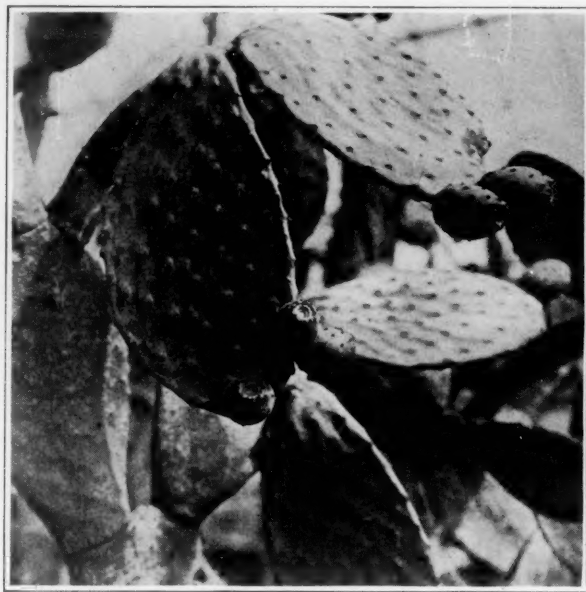
To avoid numerous difficulties it seems clear to Dr. Brues that the selection of food-plants by the Lepidopterous insects studied by him must be considered as dependent upon one or several of a number of factors. Among these he includes the following:

1. The odor of the plant and also its taste, which is no doubt closely connected with odor. Associations reasonably placed in this category would be the oligophagous species occurring, for example, on various Cruciferae, various Umbelliferæ, and various Compositæ. An additional argument for the importance of this factor is seen in the less common utilization by the same insect of several plants in a family like the Solanaceæ where a more or less similar odor does not become a family characteristic.

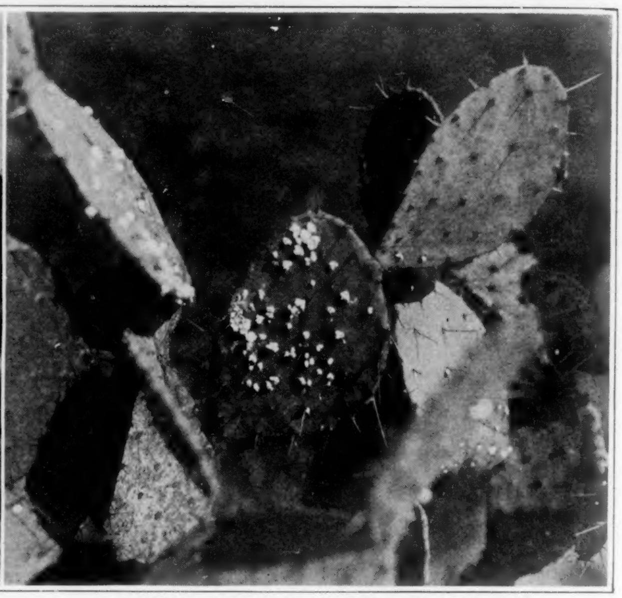
2. Some attribute of the plant, perhaps an odor, but far less pronounced to our own senses than those mentioned above. Species restricted to plants like Leguminosæ or Violaceæ may be considered in this category. Undoubtedly there is some attribute of such plants which insects can recognize in a general way and not as a specific characteristic of some single plant species or genus. The "botanical instinct" of some caterpillars that has frequently been commented upon would appear to be an exaggerated power of recognition of this sort.

3. A similarity in the immediate environment or general form of the food-plant. The effect of something of this sort is seen particularly in oligophagous and also polyphagous caterpillars feeding mainly on trees or shrubs, such as the gipsy-moth, Cecropia moth, etc., and those of certain species like some of the Arctiid moths that feed upon a great variety of low plants.

4. Apparently chance associations that have become fixed, whereby diverse plants are utilized by oligophagous species. Secondarily polyphagous species show these in an exaggerated form. On account of their comparatively rare occurrence these seem to be analogous to structural mutations, although they appear to be strictly modifications of instinct. These associations are much more apt to occur in some groups (families and genera) than in others.



OPUNTIA CACTUS FROM WHICH WE GET OUR PRICKLY PEARS



A COLONY OF COCHINEAL BUGS ON A CACTUS PLANT

The Botanical Gardens of New York

An Unusually Fine Collection of Cacti and Other Interesting Plants

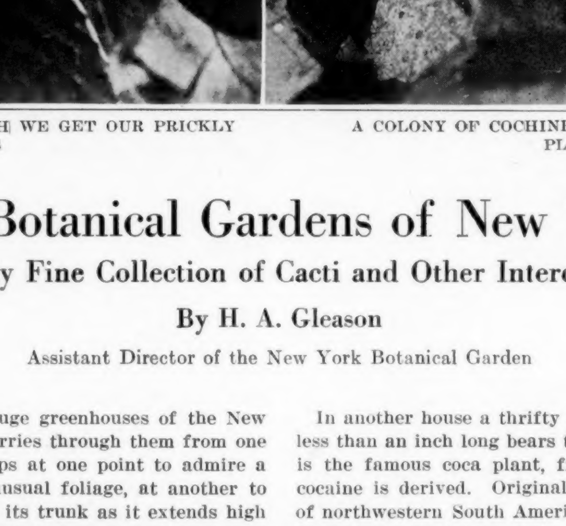
By H. A. Gleason

Assistant Director of the New York Botanical Garden

THE casual visitor in the huge greenhouses of the New York Botanical Garden hurries through them from one end to the other. He stops at one point to admire a plant with striking flowers or unusual foliage, at another to inspect a large tree and to follow its trunk as it extends high toward the dome, or again to marvel at some unusual specimen of the plant kingdom, unlike the plants of ordinary experience in its form or habit.

In such a cursory examination the visitor passes by without noticing some of the most curious and remarkable plants of the world, some of our most important economic species, and even many with delicate and charming flowers if they happen to be hidden under the foliage or appear near the summit of a tall stem.

Comparatively few visitors realize for example that the vanilla of commerce is produced from the fruit of an orchid or notice in the greenhouses the modest vine bearing that name. A zigzag stem ascends the trunk of a palm tree, bearing fleshy, glossy leaves at each angle and sending out long pendent aerial roots. Vanilla grows well under glass and reaches a length of ten feet or more, but it rarely flowers and the fruit is practically never seen in greenhouse cultivation.



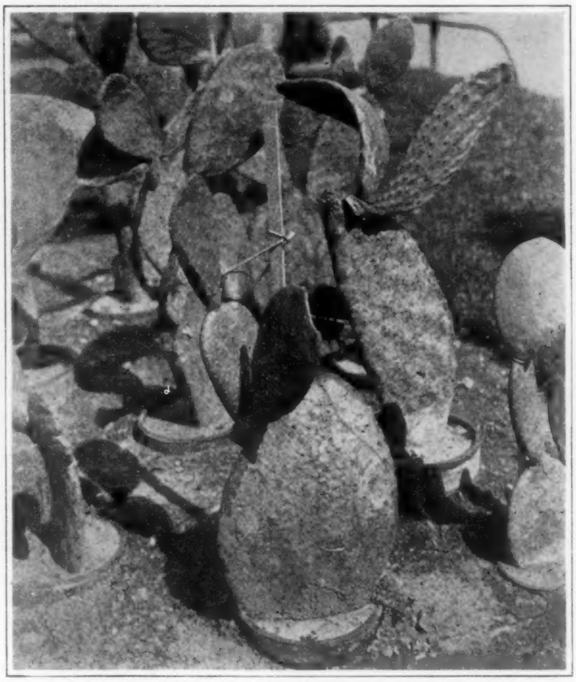
STAPELIA BLOOMS WHICH RESEMBLE DECAYING FLESH IN COLOR AND ODOR

In another house a thrifty bushy shrub with elliptical leaves less than an inch long bears the label *Erythroxylon coca*. This is the famous coca plant, from which the well known drug cocaine is derived. Originally from the mountainous regions of northwestern South America, the Indians of its native land have for centuries used the dried leaves as a stimulant. A single fresh leaf when chewed causes a slight sense of numbness on the tongue from the small amount of cocaine which it contains.

Four sections of Conservatory Range 1 are devoted to succulents, including many types of plants from many countries, but all alike in inhabiting regions with limited water supply and in storing within their bodies a reserve supply of water for use during the arid seasons of the year. These include the fleshy-leaved Crassulas of Africa and Echeverias, native of the highlands of Mexico, the similar mesembryanthemums, of South Africa, agaves and yuccas of the American deserts, aloes and gasterias of Africa, and an unusually fine representation of the exclusively American cacti.

The collection of cacti, which is one of the most complete in the world, has been brought together during the last decade by Dr. N. L. Britton, director-in-chief of the

garden, to illustrate the monograph of the cactus family prepared by himself and Dr. J. N. Rose, of the Smithsonian Institution. Four general types will be distinguished at once by the layman, the cylindrical or columnar species of the cereus type, the hemispherical echinocactus type, the jointed opuntias, and the slender, branching, thornless species of Epiphyllum and Rhipsalis. Many of the latter, with their branched stems and white or colored berries, remind one of mistletoe, a resemblance which is increased by their habit of growing as epiphytes on trees. Some of these cacti are in bloom and others in fruit at practically every season of the year. Many species, of which the night-blooming cereus is an example, open their flowers only at night and their faded remains alone may be seen during the day.



A SPINELESS PRODUCT DEVELOPED BY LUTHER BURBANK

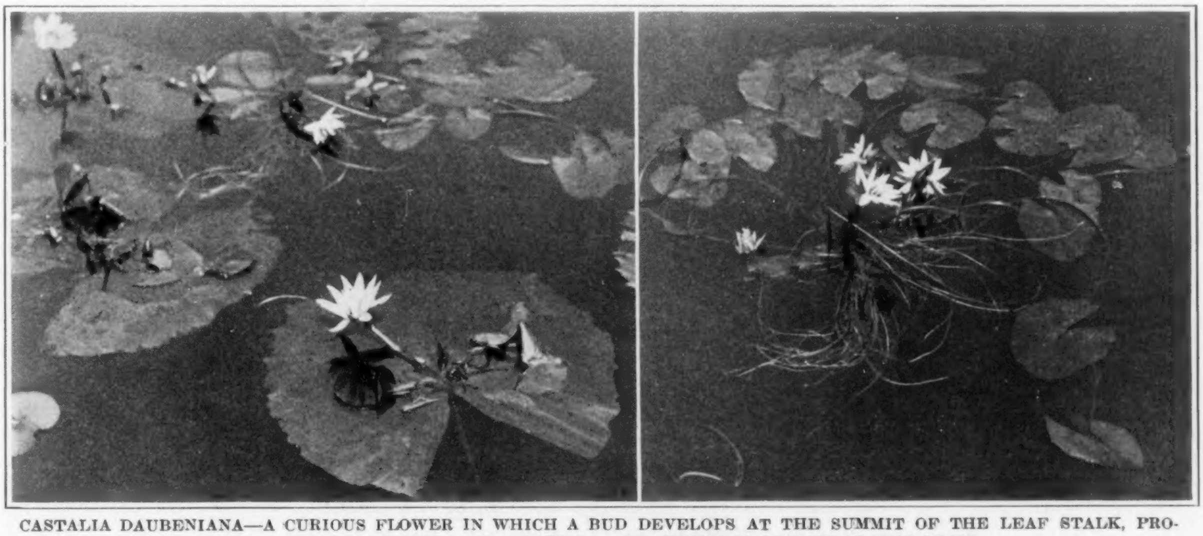
On some of the opuntia plants, the gardeners will point out the small insects from which the well known dye cochineal is produced.

Growing with the cacti are other desert plants, of which the euphorbias are so closely similar that the two are easily confused. The botanist, who can distinguish the two groups at a glance, calls this phenomenon evolutionary convergence. The layman might say that the euphorbias of the eastern hemisphere and the cacti of the western have been growing in the same hot dry desert climate for so many centuries that they have gradually assumed the same general structure and habits.

In an adjacent house are a number of small fleshy-stemmed plants two to six inches high, labeled stapelia. Few visitors notice their flowers, of which several are open at any time during the summer months. These are nearly two inches across, produced close to the ground, and of very complicated structure. They resemble decaying flesh in color, which is mottled brown and green, and in their repulsive carrion-like odor, and depend upon carrion-loving insects for their proper pollination.

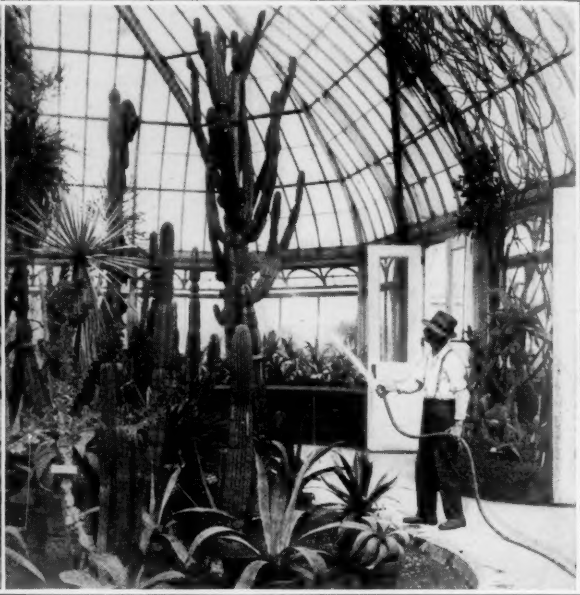
In the aquatic house numerous adaptations to an aquatic environment are exhibited. These include submerged leaves, which are almost always finely dissected or narrow and strap-shaped; floating leaves, which are broad and flaccid and frequently provided with special tissue to render them buoyant; and floating stems provided with air chambers. An interesting method of propagation is exhibited by *Castalia Daubeniana*, in which a bud develops at the summit of the leaf-stalk, produces roots, leaves and flowers and eventually separating from the parent plant starts thereby on an independent career. In this house tall plants of sugar cane are to be seen along the wall, and in the shallow water is a healthy group of the Egyptian papyrus, with tall reed-like stems. With the present shortage of paper, attention is being directed anew to this plant, as a possible source of material for the manufacture of paper.

Proper maintenance of plants under greenhouse conditions requires specialized knowledge of many species and of their individual demands, as well as careful and continuous attention to their needs. Thermometers are provided in each section and are inspected at frequent intervals day and night. The proper temperature is maintained by regulating the steam, the ventilation, and the amount of sunlight; the latter being controlled by canvas shades which may be adjusted as needed. Insect pests must be combated continuously by spraying, by fumigation or by actually washing the leaves of the larger



CASTALIA DAUBENIANA—A CURIOUS FLOWER IN WHICH A BUD DEVELOPS AT THE SUMMIT OF THE LEAF STALK, PRODUCES ROOTS, LEAVES, AND FLOWERS AND EVENTUTALLY SEPARATES FROM THE PARENT PLANT

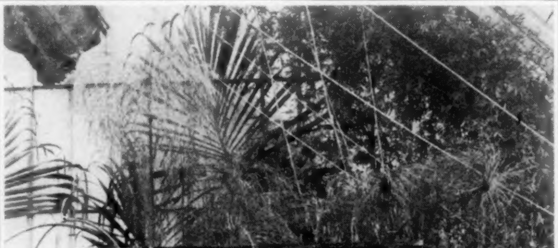
CAREFULLY WASHING OFF THE LEAVES OF THE LARGE PLANTS BY HAND TO KEEP THEM FREE OF DUST AND INSECT PESTS



EVEN THE DESERT-LOVING CACTI NEED CONSIDERABLE WATER AS WELL AS AN OCCASIONAL SPRINKLING WITH THE HOSE

plants. Even watering, simple as it seems, requires expert knowledge and is in fact one of the most particular pieces of work about the greenhouse. The skilled gardener taps the pot with his finger or gives a quick glance at the soil and knows whether they need water and how much to give them. Even the desert-loving cacti require considerable water, especially when their roots are confined in the narrow limits of a pot, and they appreciate an occasional sprinkling with the hose as well.

Propagation of new stock is done mostly in a separate greenhouse and the young plants are transferred to the public collection when they have reached a good size. One interesting method of propagation is usually in progress in the public houses, however, and attracts considerable attention. It is used chiefly for the larger trees and shrubs and is practised with great success on the India rubber and many other tropical species. An incision is made in the stem with a sharp knife, thereby interrupting the flow of sap and other food materials at that point. The stem is then wrapped with moss and kept constantly moist until new roots are formed at the cut and begin to appear through the moss.



THE GRACEFUL EGYPTIAN PAPYRUS WHOSE PITH WAS USED BY THE ANCIENTS TO PRODUCE A PAPER-LIKE WRITING MATERIAL

Then the moss is removed, the stem completely severed, and the upper portion with its new roots is set in a pot and continues its growth independently, while the old plant sends out new leaves and is actually improved by the operation.

THE OLIVE

THIS is the subject of a booklet just issued by the Research Laboratory of the Glass Container Association of America and deals very fully with the subject from the production of the olive to the method of preparing the fruit for market. It is held that the olive has been cultivated for more than four thousand years, and it is mentioned in the earliest literature. Its original home was probably in Asia Minor, being brought into Egypt during the Nineteenth Dynasty. Mummies, dating from the Twentieth to the Twenty-sixth Dynasty, have been found surrounded by olive leaves, and from Egypt its culture spread to northern Africa and thence to Greece and other parts of the Mediterranean. The tree is of slow growth, but if undisturbed persists for centuries and attains a great size. The tree is evergreen, flowers are small, and fruit of all degrees of ripeness are developed at the same time. The

TAKING A DRINK FROM THE " TRAVELLERS TREE" OF MADAGASCAR

A NOVEL SYSTEM OF OBTAINING NEW ROOTED SHOOTS FROM A RUBBER PLANT

fruit is peculiar in two respects, first, in that it contains in addition to the ordinary constituents of fruits an abundance of edible oil, and second, it contains a bitter substance which does not disappear on maturity, so that the fruit cannot be eaten at any stage of its development without preliminary treatment for the elimination of this substance. The method of treating the fruit varies in different countries. The old Romans not only removed the bitterness, but caused the olive to acquire various flavors through infusion in solutions containing aromatic substances. In removing the bitterness they were soaked in water, sometimes hot water being used, after which they were held in brine until wanted. One method called for the addition of roasted salt to the olives, after preliminary soaking in hot water, and then covering them with boiled wine or honey water to which were added fennel, mint, etc. Many recipes have been left by the ancients the preparations varying in time, strength of solutions, moisture, spices, etc. It is known that the Romans practised the use of lye solutions, sifted ashes being indicated as one of the ingredients.

Today nearly all the green olives used in the United States come from Spain, though a few are imported from Italy, Greece and France. They are hand-picked, cleaned, treated in the usual way with lye, and washed, during which process care is exercised to prevent them being exposed to the air to avoid discoloration. After grading for size they are stored in large casks of brine. The casks are exposed to the sun to favor fermentation, during which time the olives slowly change from deep green to golden. Ten per cent brine is used in the casks; but this weakens from seven to seven and one-half per cent during the curing period. The operation of stuffing consists in removing the pit by a pitting machine and filling the cavity with some other substance.

Most of our ripe olives originate in California where three pickings are made during the season in order to obtain fruit of equal ripeness. At the factory the fruit is first sorted, graded for size, and is then placed in an alkaline solution, usually sodium hydrate, the strength of which varies, but probably averages one and one-half per cent. At the end of six to eight hours this lye is drawn off, the olives exposed to the air to brown them by oxidation, and the operation repeated until an examination shows that the lye has penetrated to the pit. Clear water changed twice daily is now used until the lye and bitterness are removed, this requiring from four to eight days. The next treatment consists of a series of brine solutions, beginning with one per cent and increasing the strength at intervals of about two days until approximately four per cent is used. At this point they are ready to be put into glass cans and sealed.

Some packers allow the olive to remain in the weak brine long enough to produce an acid flavor by fermentation and others endeavor to retain the natural color rather than to induce oxidation. If it is intended to hold the olives in bulk the strength of the brine is increased until ten or twelve and one-half per cent is reached, the stronger solutions being necessary if they are to be carried through the summer.

To be sure the process as outlined is modified in practice to satisfy the conditions, taking into consideration varieties of fruit, temperature, etc. As the olives are packed the soft and defective ones are discarded and the containers are filled with three per cent brine at a temperature of 175 or 180°F. The air is then exhausted while the temperature is raised to 185° when the containers are sealed ready for processing. Processing consists in cooking in the bottle from fifty to sixty minutes, depending upon the size of the olive and the size of the container. 240°F. is reached in some factories. If a lower temperature is used the time is increased.

The history of the olive and the method of its preparation show no organisms, pathogenic to man, normally present, and hence if any are found they must come through local infection from the outside. Much research has been done by the scientific staff at the University of California along the developmental and preserving lines, and recently one of the staff has developed methods for treating the olive with aerated hot solutions which permit the preliminary treatment to be done in from three to six days instead of as many weeks, as formerly, and these methods promise to be of great economic value.

With reference to the poisonings which followed eating of ripe olives in certain cases last year a recent government report confirms the earlier finding as to the cause, but also points out that in such cases as have come to the notice of the investigators the condition of the unsafe olives were such as to give rise to an offensive odor upon opening the package such that the danger could be sensed by the average person who should refuse to serve any foodstuff that appears in any way contaminated or unfit for consumption.

The Dynamics of Plant Respiration*

A Study of the Various Forms of Energy Liberated by the Living Cell

By Camillo Acqua

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THE study of the intimate phenomena of the process of respiration—the various forms of energy liberated, their physiological significance—in short, the investigation of the mechanism of respiration, involves the examination of one of the most important problems in the entire realm of physiology—possibly, indeed, the most fundamental of all, since life is indissolubly connected with the process of breathing. Who does not know that all attempts to retain life in an organism, in the absence of the energy liberated through this process, by means of furnishing other forms of energy of outside origin, such as heat, light, and electricity, are vain? And yet respiration itself develops heat and other forms of energy which differ but little from those which we can furnish artificially to a living creature when we try to save it from asphyxia. . . . A very simple comparison will throw light upon this matter. If we wish to set in motion a steam engine, explosion motor, etc., the production of energy must take place in the machine itself. In the steam engine the coal must burn in the firebox; in the explosion motor the explosive mixture must burn in the explosion chamber. If the combustion is effected outside of itself the machine will not move, even if the same sort of fuel producing exactly the same forms of energy is consumed. And it is doubtless something of an analogous nature which must occur in the aggregates which constitute living matter. We usually define organisms as systems in which life is supported by an incessant production of energy furnished by an internal process solely, i. e., the process of respiration. This process in its widest significance is understood to be that which always results in the liberation of the energy required for supporting life, although the operation may be accomplished by various methods. Thus understood, respiration can be likewise defined as a process of *dynamogenesis*, but according to what we have said above the process in question must take place in the interior of those systems of energy which constitute the elementary particles of living matter; and if we designate these particles by the name of *plasmic micellae* we mean to indicate that the development of energy known as *dynamogenesis* must be intra-micellary in order for the micella to maintain itself in a living condition.

But if we attempt to investigate the nature of this intramicellary dynamogenesis and the method of its accomplishment, the problem presents a vexatious and baffling aspect in the present state of our knowledge. We know nothing concerning the constitution of a living micella, we know only that it may be considered to represent the simplest expression of life and that though it may thus be termed *elementary* it is none the less highly complex in nature. As to the real character of the energetic phenomena which take place within it, we are totally ignorant. And in any attempt to penetrate its mysteries we must seek an indirect method; when we try to throw some little light upon the obscure problem of the liberation of energy within the micella, we are obliged to study external phenomena and their relations. Similar indirect methods have been necessarily employed in the study of the intimate constitution of molecules and of atoms. The difficulties in studying the elementary particles of living matter are undoubtedly even more difficult than in the case of nonliving matter, for we are still far from possessing a satisfactory physical chemistry of living matter. Hence we must content ourselves, at present, with merely preliminary researches.

In this domain, as in so many others, the studying of plants must precede that of animals, since the former exhibit a simpler structural plan and since, furthermore, this examination constitutes an excellent preparation for that of the more complicated questions of general biology.

We will commence, therefore, by studying the phenomena which fall under our observation and investigating the external forms of energy liberated by respiration and the processes which contribute to this liberation. We shall likewise examine the nature of the materials employed to furnish energy and from the ensemble of these facts we shall seek to derive a point of support for some induction which will enable us to represent, in however preliminary and approximate a fashion, the mechanism of respiration.

That phenomenon of energy which is most closely connected with respiration is the production of heat. In only a very few cases do plants emit light; as for elecrtic energy, while it must be regarded as of considerable importance, it is not manifested as a direct consequence of the respiratory process, at any rate so far as we now know. With respect to mechanical energy plants exhibit continual examples, but it likewise is unknown to us as a direct manifestation of the process of respiration. Thermic energy, therefore, constitutes the most important form of energy developed in the course of this process. It is this which has chiefly engaged the attention of the men of science who have made research along this line.

While the production of heat is slight in most cases it is always easy to demonstrate, when we prevent its dispersion, and during periods of active vegetation. Sometimes, however, this thermogenesis may become very considerable: this is what happened in certain fermentations, and it also occurs in exceptional cases among the higher orders of plants. As an example of this we may quote the well known case of the *Arum Italicum* whose inflorescence terminates in a swollen organ which has been termed a "club" by reason of its form. In this instance the development of heat is so intense that it can be detected by means of mere contact with the hand. Coincident with this thermogenesis is a very active combustion of the carbohydrates contained in the club, which are consumed in the course of a few hours. The connection between physiologic combustion and the production of heat is, therefore, very evident in this case.

An endeavor has been made to discover the actual quantity of heat in calories given forth in such instances. Among those who have been particularly interested in this question I may mention Bonnier and Peirce. According to the latter the germination of peas occasions the production of 4.93 calories per day for each gram of weight; the figures given by Bonnier are even higher. But the researches of the last mentioned authority are of importance from another point of view. When complete oxygenated respiration is accomplished, i. e., when the carbohydrates undergo combustion until they have produced as final products water and carbonic anhydride, a quantitative analysis of this gas will give an idea of the amount of heat generated. M. Bonnier has endeavored to determine whether the estimated heat corresponds to that actually emitted. The problem is difficult since this very delicate investigation is more or less disturbed by the other processes which are constantly developing in the organism; nevertheless, M. Bonnier succeeded in determining in some cases that the heat emitted was less than that estimated, which indicates obviously, that a part of the energy produced in the respiratory dynamogenesis, instead of being transformed into heat, is retained, probably serving to support

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the intimate energetic processes of the plasmic micellae. A new question then arose: What is represented by that part of the energy—the greatest part—which is manifested and dispersed in the form of heat? But all those who have studied this question are unanimous in the belief that it represents a loss except in a few special cases. According to this there must be a great dispersion of energy, analogous to that which takes place in ordinary steam engines, during the course of the physiologic combustion of living matter—at any rate in plants.

Another question which is likewise of great importance is that which concerns the materials which support this physiologic combustion, especially in the higher orders of plants. We cannot here enter into this question in detail but will confine ourselves to reminding the reader that the respiratory materials of the first order are furnished by glucose; there is no doubt of the fact that during physiologic combustion this substance is decomposed and oxidized either partially or completely, the terminal products in the latter case being water and carbonic anhydride. But glucose is a ternary body, composed of carbon, oxygen, and hydrogen; it cannot constitute living matter and we find it, in fact, in the cell, where it is often located in the vacuoles. And how then shall we reconcile this fact with the opinion that combustion must be produced in the interior of the energetic systems which characterize life, *i.e.*, those of intra-micellary nature? Two theories may be formulated with regard to this subject: either the molecules of glucose—and the same reasoning may be applied to all other bodies capable of acting as respiratory materials—must be connected in some manner with the micellae of living matter; or else the proteic substances which constitute living matter are capable of being decomposed so as to produce glucose as a respiratory substance, and of regenerating themselves latèr at the expense of some other glucose or other ternary bodies derived from the surrounding medium. According to this last hypothesis the glucose is the substance which burns, not because it takes a direct part in the combustion, but because it is a product of the destruction of the living matter. These theories have been extensively discussed and many arguments have been offered on each side; I will content myself with saying that either is possible and that either is in agreement with known facts as well as with the hypothesis of intramicellary respiration.

But at this point another question suggests itself: Is it necessary to admit that this conception is available for all the processes of dynamogenesis, including also the cases in which a process of abundance is concerned, such for example as the instance cited above of the generation of heat in the club of the Arum Italicum? This question, we believe, may be answered as follows: It is probable that in these cases a large part of the ternary bodies may undergo direct physiologic combustion; possibly it may be a case of an accessory respiratory process which might be termed *false respiration*. This process also might have its *raison d'être* in the special exigencies of the organism without being considered as strictly necessary nor as connected with the intimate energetics of the living micellae.

Thus we have arrived at the concept of a proper energy which is characteristic of living matter and which must consequently be quite distinct from the secondary processes which are met with in the organism. And just here we crave permission to make a brief digression.

Our present knowledge concerning molecules and atoms is of such a nature as greatly to facilitate the formation of a working idea of the constitution and energetics of a living micella. Since it has been discovered that the atom is not an indivisible corpuscle, but rather a little cosmos composed of other particles which in the present elementary condition of our knowledge must be considered as the smallest masses of matter which exist, it is possible to gain a concept of a special intra-atomic energy due to the movement of the individual corpuscles which compose the atom. Thomson, to whom we are indebted for certain brilliant speculations concerning this matter, designates this form of energy by the term *corpuscular* energy. If we afterward examine more complex aggregates, such as molecules, we find that they constitute other systems in which the atoms themselves function as units, i. e., in which they may be regarded as being reduced to so many particles of matter having the power of moving and of changing their position in the same manner that the planets move in unison with their train of satellites in the solar system. But molecules, too, are the seat of a special form of kinetic energy which may be termed in agreement with the ideas referred to above, *molecular temperature*. And just here we may quote Thomson once more to the effect that there probably exists no very close relation between these temperatures. Furthermore, we can conceive of molecules as being more or less complex until we arrive at those very complex ones which constitute the albuminoids, *i.e.*, those substances within which life is capable of being manifested. But in all these cases the same laws which govern the inorganic world also prevail.

Let us go one step further and consider the phenomenon of organization. Thanks to this the simple particles which we have designated as plasmic micellae acquire new properties; and by taking this last step we have crossed a definite line of demarkation and find ourselves concerned with new systems of a far more complex nature, in which phenomena must occur which can no longer be regarded as identical with those which take place in the interior of a molecule or of an atom. And here we find ourselves concerned with a special form of energy which is evolved in the interior of such systems and thereby supports life. And just as Thomson has called the kinetic energy of the atom *corpuscular temperature*, and the kinetic energy of the molecule, *molecular temperature*, we may give the name of *micellary temperature* to this special energy which is characteristic of the plasmic micellae, *i.e.*, of the elementary living particles. But since Nature exhibits an indisputable continuity in her laws, and since even when she seems to make an abrupt leap, she always presents certain bonds and connections between the different links in the great chain of her phenomena, we must seek to apply in the present case the same general concepts which have been of service in the study of other aggregates, especially of those constituting molecules and atoms. As we have said, Thomson points out that there probably exists no direct relation between *corpuscular and molecular* temperatures. These concern forms of energy which develop in systems which are not only different but largely independent of each other; we must endeavor to ascertain by analogy whether *micellary temperature* likewise represents an autonomous form of energy which is in great part independent of other forms and more particularly whether it is independent of *molecular temperature*, since molecules are the aggregates which most closely resemble living micellae. And since we are obliged to believe that there is a close connection between this molecular energy and the temperature revealed by the thermometer we must ask whether it will be possible to affirm the independence of the vital phenomena with respect to thermic energy. At first glance this question appears to demand a negative response; everyone knows how much influence temperature exerts in general upon the conditions of development which affect living creatures. But upon more profound examination we perceive that this judgment must be modified. We must not forget that during the vegetative period when the various processes of nutrition, growth, division, etc., attain a considerable degree of development, the respiratory process is accompanied by a number of other metabolic processes which depend, without doubt, upon external conditions, and which may also indirectly influence the respiratory process. In this case the phenomena observed are multiple, influencing each other and thus rendering it difficult to study the intimate nature of the process of dynamogenesis.

But there is another period in the course of which the various manifestations of the vegetative life are quiet, when

growth and cellular division are suspended, and when the chief process observable is that which possesses the power of maintaining life—namely, the process of respiration. This period, which is called the period of repose, obviously best lends itself to our investigations. We find at this time a great independence between the respiratory process and the other external forms of energy. The spores of bacteria are in general very resistant and sometimes support without injury a temperature considerably higher than 100° C. (212° F.). Seeds also are usually very resistant *both to heat and to cold;* thus Becquerel kept certain seeds at the temperature of liquid air for three weeks, and at that of liquid hydrogen for seventy-seven hours without destroying the germinative power in the great majority of them. And since it is impossible to conceive of life as existing without the respiratory process, we are obliged to conclude that the intra-micellary energy which we have termed *micellary temperature* also represents a form of energy which is quite distinct from other forms of energy and which is in great measure independent of them.

Thus, *corpuscular temperature, molecular temperature, and micellary temperature* represent the three forms of energy which exist in the interior of the three characteristic systems; namely, the atom, the molecule, and the living micella.

In the course of his brilliant speculations Thomson considers the cases in which, by reason of an effective elevation or an excessive diminution of intra-atomic energy, the system constituting the atom is unable to continue to exist, but is forced to disaggregate. . . . According to Thomson the constitution of the aggregate cannot be retained except when its internal energy is comprised between two limiting values which constitute its "critical values." But these concepts, which may be applied to aggregates of a higher order, i. e., to molecules, are likewise applicable by analogy to the plasmic micellae. Hence we are forced to believe that in order to maintain life the *micellary temperature* must be comprised between two extreme or limiting values. This enables us to give to the idea of death a definition which is new and possibly more exact than any hitherto proposed by saying that death occurs when the *micellary temperature* exceeds one of its limiting values. The action of certain poisons can thus be explained if we admit that they exert an influence upon the dynamogenesis by saying that they either exalt or depress the *micellary temperature.* And in the first of these two cases it can be readily understood that a partial or moderate exaltation may be favorable to the organism while an excessive exaltation may cause death. This would also explain the singular properties of certain toxic substances which act as excitants when administered in small doses, but produce death when the doses administered exceed a certain amount.

In this study I have sought to give a brief résumé of the dynamics of the respiratory process so far as we understand it at the present time (1915). Furthermore, I have attempted to apply certain general concepts derived from modern researches concerning the constitution of matter to the special case of matter which is organized and which is consequently living matter.

In attempts of this sort it is, of course, proper to proceed with caution, confining ourselves to general concepts. We are just beginning in fact to establish a physico-chemical science of organic matter and any hypothesis of too specific a character would run the risk of proving to be absurd. We need to make new researches and to discover other facts, other relationships, and other laws. Biology will not be able even to attempt the solution of its most difficult problems until it is possible to coördinate all the facts collected into a rational system and to utilize the assistance of definite mathematical laws. It is useful, none the less, to state the problem at the present time, so that we may, at least, indicate the direction in which future investigations must proceed.

New Theories and Methods of Vaccination

Collateral Immunity, Bacterio-therapy, Entero-therapy, and Vaccino-therapy

LITTLE did the famous Dr. Jenner foresee when he inoculated a patient for the first time with the pus of a bovine animal suffering from cowpox, as a means of protection against the dread scourge of smallpox, which at that time was not only killing thousands of people annually in nearly every country under the sun, but was hideously disfiguring hundreds of thousands of others, that he was lifting the edge of a curtain behind which was still concealed a knowledge of the causes and the cure of infectious diseases, which when fully revealed would confer enormous blessings upon all mankind.

Not only have widespread epidemics of smallpox become practically a thing of the past in civilized countries, by reason of the now nearly universal practice of compulsory vaccination of children, but similar methods have been successfully employed in case of many other devastating infectious diseases, such as yellow fever, typhoid and para-typhoid fever. One need not be very old to recall the shocking fact that during the Spanish War more soldiers were said to have died from typhoid fever while still in camps on American soil than were killed in battle among that part of the expeditionary force which succeeded in reaching Cuba. Contrast this with the fact that in the Great War recently ended typhoid fever was regarded as a menace not among the armies, whether in camp or at the front, whether in America or on French soil, but only among populations where for one reason or another, such as lack of supplies or inaccessibility it was impossible to vaccinate the people with the proper serums.

But great as was the boon conferred upon the human race by Jenner in checking the ravages of smallpox, it was not until Pasteur and Toussaint began their famous researches that vaccino-therapy or the treatment and prevention of infectious diseases by means of vaccines really entered into its kingdom. And even then there remained many people not only unconvinced of the efficacy of vaccination but actively hostile to it, even to such an extent that in many places anti-vaccination societies were formed. Pasteur and Toussaint extended the practise of vaccination to the two terrible diseases, anthrax and rabies, which while generally confined to animals are communicable to men and have counted many victims among the latter. Sir Almoth Wright, later, treated the bubonic plague and staphylococcic infection by vaccination.

But the researches of bacteriology during the present century and, particularly, during the war, have vastly extended not only the use of vaccination but also our very ideas as to the nature of its operation. It is the object of this article to set before the reader a brief account of the most recent theory and practise in the closely related subjects of bacterio-therapy and entero-therapy, as well as vaccino-therapy in general.

VACCINO-THERAPY

The practise of vaccination is based upon the proved fact that disease germs occasion in any organism which they infect certain reactions by which the body endeavors to defend itself against the invader. These reactions are characterized in part by the formation of certain specific substances which are capable of destroying the said microbes and, indeed, of destroying these in preference to others. These substances have received the name of anti-bodies. Even after the recovery from the infectious disease in question a number of these anti-bodies persist in the blood of the patient for varying

lengths of time, sometimes amounting to a number of years. It is this persistence of defensive anti-bodies in the blood of an individual, which confers upon him immunity from a fresh attack of the disease, and if the serum of blood thus highly charged with specific anti-bodies be introduced into the system of another person in danger of infection through exposure to the same disease, this latter individual will likewise acquire immunity by this vicarious method of vaccination. Obviously, too, an animal may be so prepared that its blood will contain a high percentage of the anti-bodies, characteristic of a given infectious disease. If the blood from this animal be drawn off—in quantities, of course, not so large as to injure the animal—the serum from it can be bottled and kept as a specific for the treatment of the disease in question or for its prevention. When such a serum is injected into the body of the victim of the same disease, the patient receives a welcome increase of the anti-bodies which he requires to combat the infection from which he is suffering. This form of vaccination is specifically known as sero-therapy, but while sero-therapy is of assistance in effecting a cure and gives an immediate protection, this protection is of short duration and is *passive* in character.

But when, on the other hand, instead of injecting the serum containing previously formed anti-bodies, the bacilli, which occasioned the disease, are themselves injected, a direct appeal is made to the latent defensive power of the organism itself. In other words, the body is forced to augment its resistant power and to intensify its means of struggle. In such a case the effect produced does not follow so quickly as when serum is employed but it is, on the other hand, far more energetic and more lasting. The protection or immunity thus attained is said to be *active*, since the organism has acquired it by its own efforts to produce a defensive reaction. This is the fundamental principle of vaccino-therapy.

It follows, furthermore, that if for one reason or another, the organism fails to react to the vaccine, the latter remains without efficacy. Naturally, too, if the vaccine itself is imperfect, as sometimes happens, and, therefore, incapable of producing the desired reaction, there is no result. As a matter of fact the results obtained by vaccino-therapy are quite variable, and this fact is used as a weapon by its opponents. Only by experiment can a discrimination be made between vaccines which are active and those which are ineffective.

THE TECHNIQUE OF VACCINATION

Technically speaking vaccination consists of introducing into the organism emulsions of the same microbes as those which cause the malady from which the patient is suffering or against which it is desired to obtain immunity. These injections are usually either subcutaneous, intra-muscular or intra-venous, in which case the introduced substance passes at once into the very tissues of the body. But as we shall see later the vaccine is sometimes introduced into the alimentary canal, either by the mouth or otherwise. Vaccines thus employed are known as entero-vaccines since they pass into the body not by direct injection but through absorption from the digestive tract. We shall recur to this subject later.

Vaccines must be given, of course, in definitely prescribed doses. These doses are dependent upon the number of microbes per cubic centimeter contained in the solution; the average dose is one containing 500,000,000, which corresponds to an approximate weight of 1 milligram of microbes. When highly active curative vaccines are employed, the average dose at the beginning is only one-tenth of this, *i.e.*, one containing 50,000,000. This initial dose is doubled, tripled, etc., in the following injections which should be made at intervals of not less than three or four days and not more than eight days. But the absolute number of microbes injected also depends upon their species and upon the case in question; it may be larger when preventive vaccination is employed. The lipo-vaccine and those made up with iodine are those which are best tolerated, while heated vaccines come next to these.

As we have said the injections may be either hypodermic, intra-muscular or intra-venous, but the latter form is rarely employed because of the violence of the reactions employed, which sometimes entails serious consequences. Usually the injction is the first form, *i.e.*, beneath the skin. The location chosen for persons not confined to bed is generally the lower spinal area, while for others the deltoid or sub-clavicular regions or else the flank is selected.

However, more recently some doctors, including Lumière and Danysz, have advised "mouth vaccination" by means of the so-called *entero-vaccines*. Particularly in typhoid fever, cholera, and certain forms of dysentery; these are advised mainly as preventive vaccines instead of curative vaccines. Dried vaccines are administered by the mouth; Dr. A. Fournier and Dr. Schwartz have obtained some interesting results by this method.

The reactions produced.—The injection of a vaccine causes both local and general reaction. Among the former are pain at that point of the skin (by the hypodermic method) where the vaccine is introduced, together with a redness and swelling which may last for two or three days; sometimes, too, the corresponding nerve ganglia also swell and become painful. The general reaction produced is more or less acute according to the method of injection employed. Its chief features are fever (39° C.), headache, discomfort, general stiffness, etc., lasting from twelve to twenty-four hours, but when two large doses are employed at the beginning or when the vaccine is injected into a vein very serious symptoms may appear, such as intense discomfort, shivering, syncope, high fever, etc.; such symptoms are, however, usually of short duration. Finally, kidney disturbances may appear (albuminuria, hematuria, urenia) and pulmonary troubles (the cough of tuberculosis).

Such results indicate that great caution must be used in employing vaccines for persons suffering with tuberculosis, acute nephritis, arterial-sclerosis, jaundice accompanied by a large liver, collapse, tachycardia, with myocarditis, ataxo-adynamic conditions, etc.

The more profound effects of injection.—The more profound reaction produced by the injection of a vaccine present two phases. The first of these which appears almost immediately is indicated by what is known to physicians as a *hemoclasic crisis;* this is marked by a decrease in a number of white corpuscles or leucocytes by a modification in the properties of the serum and in the coagulability of the plasma and by a diminution in the oxonic index.

This primary phase corresponds in part to what Dr. Wright terms the *negative phase*, during which the organism appears to exhibit less resistance to the infection. This phase is followed by the reactionary phase proper known as the diaphylactic stage; this is characterized by an increase in the number of leucocytes, which are at first poly-nuclear and afterward mono-nuclear, and also by a rise in the oxonic index and by a recovery of its normal composition on the part of the blood (48 hours on the average). At the same time the fever goes down, the gravest symptoms become milder, and the invalid feels considerably better. This latter phase lasts for several days and may even be definitive and followed by entire recovery. Consequently when curative vaccines are employed there is no use in renewing the injection until this latter phase has come to an end, whereupon if there is no recovery the more serious symptoms may show a fresh tendency to increasing gravity. In the same way it is important not to repeat the injection during the negative period, since this might increase the depression of the body's defensive powers, which occurs during this period. This is why there should always be a lapse of at least three or four days between the injections.

Preventive vaccines exhibit similar reactions but usually with less intensity; but it is none the less necessary to allow a proper lapse of time between the injections, in order to attain actual immunity (anti-typhic vaccination). Finally, it should be noted that these phenomena of reaction possess

merely the usual significations and depend not upon the nature of the vaccine but namely upon the mere fact of the introduction of foreign bodies into the tissues of the body which results in a hemoclasic crisis. This is why *all vaccines, no matter of what nature, produce reactions of the same kind.*

Entero-vaccines.—In most infections which have their origin in the intestines, such as typhoid and para-typhoid, fever, cholera, coli-bacillosis, etc., the disease occurs because the pathogenic microbe have been incompletely digested by the digestive juices; those which escape pass into the circulation where, acting as anti-gene, they produce the various reactions which constitute the symptoms of the disease. The manifestation of the disease is thought by Danysz and some other authorities to be due to chemical combination within the body, but a more modern view which is the one held by Dr. J. Laumonier, to whom the writer is indebted for much of the material in this article, is that the symptoms of the disease are due to a struggle between the colloids of the organism and the foreign colloids suddenly introduced into their midst.

But it is a well known fact that by methodical training, the secretions of the stomach and the intestines can be educated, so to speak, so that they will be capable of completely digesting substances which usually they attack only slightly or not at all; a well known example of this is that fowls may be trained to eat meat while dogs and other carniverous animals can be trained to digest bread and other vegetable food. This has suggested the theory that if susceptible individuals could be dosed systematically with cultures of the bacilli which produce intestinal infection, they might thus gradually acquire immunity to these infections both because the alimentary canal has been gradually accustomed to digest such bacilli, and because the defensive reactions of the body have been augmented.

From this point of view, of course, entero-vaccination is purely preventive. But the method has been extended to cases of disease where the patient is too feeble, from extreme youth, old age, or a chronic malady, to support the more violent reactions of ordinary vaccination.

In 1912 Courmont and Rochaix first employed stock vaccines of Eberth bacilli which had been sterilized by heat in enemas for typhoid fever; they thus obtained very encouraging results and notably a more rapid subsidence of the fever defervescence. Later Lumière and Chevrotier advised a poly-vaccine composed of Eberth bacilli and para-pythic bacilli, sterilized and dried in the form of keratin pills administered by the mouth as a cure, but chiefly as a preventive for cases of para-typhoid fever and dithien-entry. During the war L. Fournier made use of liquid culture of the Eberth bacilli and of the para-pythic bacilli A and B, sterilized at 100° C., and either swallowed in a little sweetened water or else administered in enemas. In many cases this was found to have a very favorable action causing the fever to disappear and the disease to run its course more quickly. Finally, Danysz recommended entero-vaccination chiefly as a preventive in cholera and infections due to coli-bacilli.

BACTERIO-THERAPY

The comparatively new treatment known as bacteriotherapy is all too frequently considered a synonym for vaccino-therapy; since this is incorrect, let us at once define the former; whereas the latter term is very inclusive comprising all the methods by which any sort of microbes are employed as curative agents, bacterial therapy signifies specifically the treatment of certain infectious maladies by means of microbes different from those which have caused the said maladies. The English physician, Dr. Wright, who was one of the first to make a study of this process, soon observed that the microbes employed act according to a different mechanism in the two cases. When a patient suffering from a staphylococcic infection has a culture of the same bacilli injected into his system, the result is to reinforce the natural defences of the body against the staphylococci which have invaded it, and against these chiefly, whereas, if a typhic patient is injected with cultures of pyoscyanic germs its defences are not reinforced against the Eberth bacillus in particular, but merely in a general and non-specific manner against a state of infection; hence the distinction now generally accepted by advanced authorities between vaccinal therapy which provides immunity against a given microbe and against it alone, and bacteriotherapy which furnishes no specific immunity but causes an ordinary increase of intensity in diaphylactic processes.

As stated in an earlier portion of this article these results are dependent essentially upon the fact that the introduction into the organism of foreign bodies increases the number of leucosites, and intensifies the activity of the bodily secretions, to the end that the intruding bodies are finally destroyed. It must be remembered that these effects do not depend upon the actual microbes themselves, considered as microbes, since they are capable of being produced by very different bodies, such as sugar, peptone, the various serums, colloidal metals, etc. This very new branch of science is still being studied. When first employed microbes were taken which were supposed to be antagonistic to those which it was desired to combat. Thus yeasts were recommended for boils and carbuncles and staphylococcic affections in general and lactic and paralactic bacilli for intestinal affection, but Dr. Wright, continuing his researches that the inoculations of a vaccine designed to combat the bubonic plague also combated eczema and blennorhagia, while anti-typhic inoculations combated malaria.

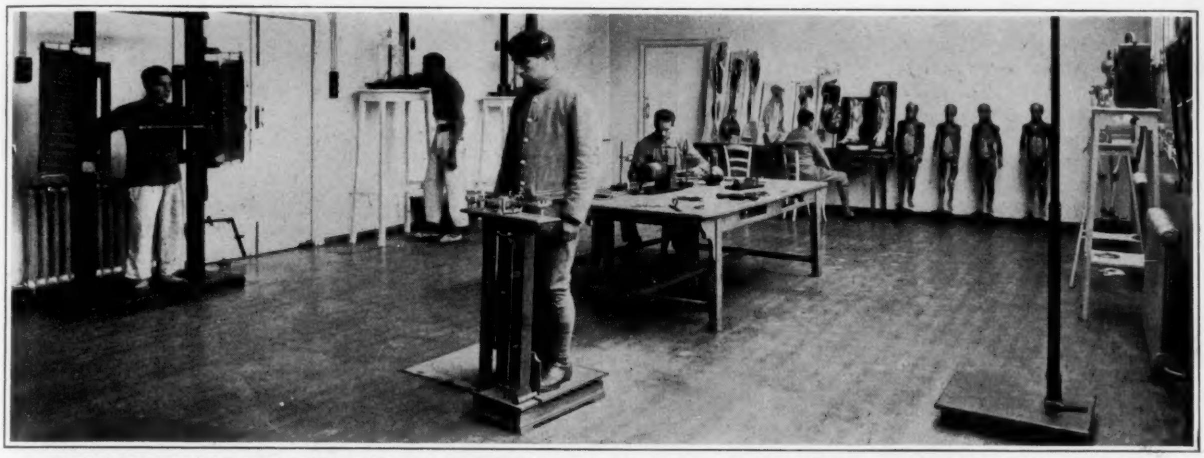
Collateral immunity.—Wright, therefore, concluded that besides their specific action vaccines possess a general protecting action to which he has given the name of "collateral immunization." This new idea is being widely studied not only in England but in this country and in France. Some of the principal effects observed are as follows:

Injections of anti-typhic vaccine have been found to cause improvement in certain cases of articular rheumatism, eczema and tuberculous lupus; reciprocally sterilized cultures of pyocyanic and coli bacilli and of coli bacilli have produced favorable results in typhoid fever as have also cultures of *proteus*. The English make use of cultures of staphylocci for pneumonia, while in America sterilized Eberth cultures are used to fight the same disease.

Nicole and Blaizot have even recommended a vaccine intended to combat tuberculosis; this is an anti-staphylococcic vaccine. Cépède recommends for the same purpose a vaccine composed of streptococci, staphylococci, pneuomococci and entereococci. However, these tuberculosis vaccines are directed rather against the secondary infection of tubercular lesions than against the tubercular bacillus itself. Finally, Delbet and Robineau employ a complex vaccine to combat all infections which are accompanied by suppuration, such as anthrax, abscesses, and infected wounds or burns. This vaccine is prepared by "aging" the culture, and in consequence of this the products of autolysis are concerned in its activity. The technic of bacterial-therapy is the same as for vaccinotherapy described above.

WARM FEET IN BED

QUITE apart from the comfort of the matter it is recognized that on health grounds it is important to have warm feet in bed. A British physician has described a novel method of securing warmth for the feet. A paper tube about three feet in length is prepared by rolling a big sheet and pasting the edges together. When the person is in bed this is pushed down under the clothes toward the feet. The upper end of the tube is held close to the mouth and the following method in breathing is adopted. The fresh air is inhaled through the nose and the exhalation is made through the mouth down the tube. As a result there is a current of warm air continuously being poured into the bed. In quite a short while the feet become comfortably warm and the tube may then be discarded.—By *S. Leonard Bastin.*



GENERAL VIEW OF THE MAIN HALL OF THE PHYSIOLOGICAL LABORATORY OF THE FRENCH ARMY AT JOINVILLE
(Note the Demeny double conformator at the extreme left)

The Cult of the Sound Body

Apparatus Employed in Modern Physiological Laboratories to Test Physical Development

By T. V. Davidson

ONE of the vital lessons pressed home by the war in every country engaged therein, was the unsuspected and in some cases even appalling percentage of physical defects found in the youth of the populace, and that at the very age when they should be in their physical prime. In spite of the fact that the modern development of machinery has rendered the actual physical prowess, which is all important, in the hand to hand fights among savages and primitive peoples less imperative, it was early recognized that no matter how big the caliber of the gun, how long its range, it is, in the last analysis, the man behind the gun that counts. In certain branches of modern warfare, indeed, the faultless working of the human machine is of even more vital import than in the Wars of the Roses. While the aviator, for instance, may require no great strength of muscle, it is imperative that he should possess a perfect coördination of muscle and a perfect response of muscle to nervous impulses; again, the proper functioning of his sense of equilibrium may at any moment be a matter of life and death. These things are so obvious that experimental tests for candidates for aviators were among the first to be introduced in the various armies engaged in the recent great struggle. Evidently, too, there are certain physical defects making it inadvisable for their possessor to undertake diving or submarine work.

Muscular Training.—It is no longer thought desirable to develop one set of muscles enormously at the expense of others and, indeed, this practise frequently proves very harmful in later life, as in the case of athletes whose college activities are suddenly changed for the more sedentary pursuits of a business or professional career. Yet more and more it is being realized that a well-balanced development of the muscles of the entire body exerts a favorable reaction upon the health and vigor of the individual, and this applies not only to his external, physical organism, but to the internal organs since judicious muscular exercise promotes at once the circulation of the blood and the excretion of waste matter from the skin and the other organs whose functions it is to get rid of the ashes and clinkers, so to speak, which would otherwise clog the engine.

But this is not all—no less an authority than the distinguished psychologist, Dr. G. Stanley Hall, makes the following significant statement in his remarkable work entitled "Morale," a word by the way which he defines as "the supreme standard of life and conduct":

"The muscles are nearly half the body weight. *They are the organs of the will which has done everything man has accomplished*, and if they are kept at concert pitch the chasm between knowing and doing which is often so fatal is in a measure closed.

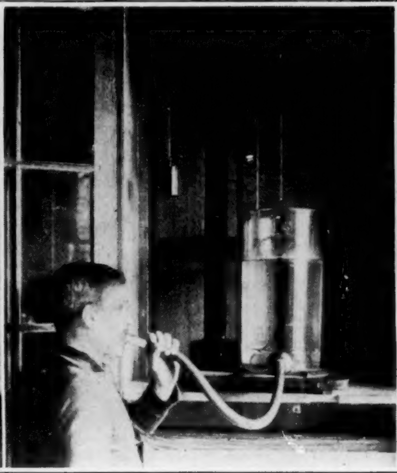
"There is no better way of strengthening all that class of activities which are ascribed to the will than by cultivating muscle."

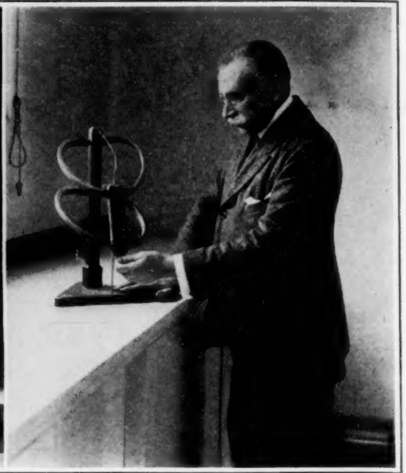
These weighty words are worth being pondered seriously and one of their clearest implications is that each group or set of muscles must be studied separately and subjected to the special training it requires. Moreover, the various systems of muscles must be studied in relation to each other and, if necessary, made to coördinate harmoniously. The muscles required by the typist and the dancer are far apart, to be sure, and at first thought those required by the pedestrian and the oarsman seem equally unrelated. And yet when the writer was a student at Cornell, it was a common saying that the superior ability of the crew was due not only to the efficient training of the veteran coach, and the steady practise on the blue water of Lake Cayuga, but largely to the fact that the toilsome climb up the long hill from the lake to the campus developed the leg muscles and backs of the men so as to give them greater staying power than their rivals.

POST WAR SCHOOLS FOR PHYSICAL TRAINING

So marvellous was the improvement in the physical condition of many recruits, from the physical training given them before they were considered fit to go into action, that it was a matter of common remark that the erect, well set up troops who had undergone such intensive training could hardly be recognized as the same flat-chested, round-shouldered, spindle-shanked recruits who had come slouching into camp a few months before. It is encouraging to note that this sort of special training has not been dropped with the cessation of hostilities. The work is developing, indeed, on a larger scale than before, and it is the purpose of this article to describe some of the special apparatus devised, particularly in France and in Germany, for testing the physical condition of the applicants for training.


VERDIN SPIROMETER FOR TESTING THE CAPACITY OF THE LUNGS


INSTRUMENT FOR MEASURING THE VOLUME OF AIR EXHALED


MODEL ILLUSTRATING INFLATION OF THE RIBS DURING INHALATION

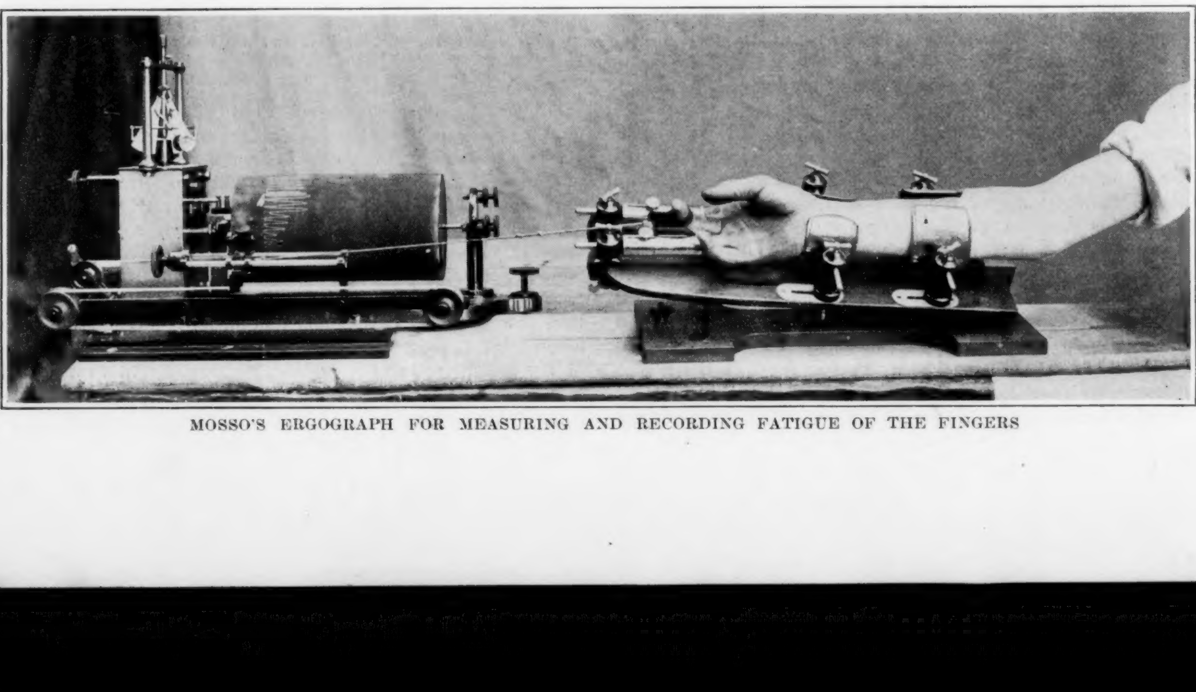
One of the most interesting of these schools is the physiological laboratory of the French army newly established in the quarters left vacant by the Canadian army in the forest of Vincennes and known as the *Ecole Joinville*. This laboratory is a sort of annex for scientific experimental work attached to the normal school of gymnastics and fencing at Joinville (Seine). At its head is Dr. Boigey, physician in chief. It contains an extensive assortment of apparatus including the recorders and meters employed in physiology and in psychology for such various purposes as the observation of muscular contraction of the circulation of the blood, of the respiratory process, and instruments for measuring the form of the body, both at rest and in motion. It also includes a chemical laboratory and studios for photography and chromophotography. Most of the apparatus employed has been specially invented either by Dr. Boigey or by Professor Demeny of the *Course of Physical Education* of the City of Paris.

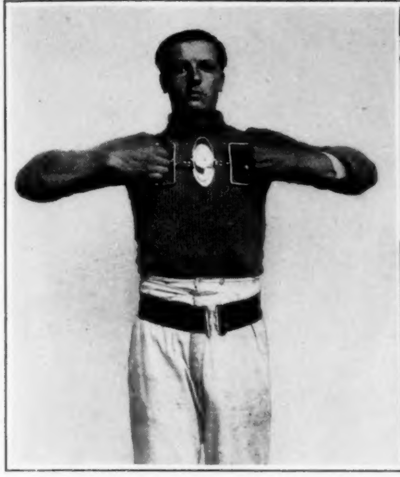
Measurements of the chest are made by means of a special compass with ivory points; one of these points is on the end of one of the legs while the other forms the end of a rod attached to a spring-pressed pointer which can be moved at will over a graduated index. Thanks to this arrangement the compass can readily be withdrawn without opening it and without wounding the subject of the examination; the elasticity of the spring keeps the rod provided with the ivory button constantly in contact with the chest of the subject while at the same time allowing his respiratory action to proceed without interference. Thus the path of the rod measures the increase in diameter of the thorax during inspiration and its variations can be readily recorded by means of a Marey drum.

In order to obtain all the measurements of the body with the utmost possible degree of precision, Professor Demeny has contrived a "*universal double conformator*" by means of which there can be inscribed upon a sheet of paper the various sections of the trunk in a vertical plane passing through the spinal column and in horizontal plane, taken at different heights of the thoracic cavity. The essential members of the apparatus consist of the series of wooden pins which are movable about rigid axes and which are capable of being fastened either horizontally or vertically upon a framework. The ends of the pins are placed in contact with the spine or the portion of the body to be profiled and are then fixed firmly by means of a clamp. Since the latter can be detached from its vertical support, it is easy to copy on paper the profile indicated by the pins.

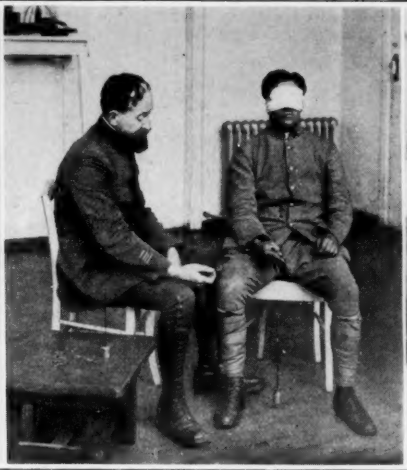
By means of two series of pins held parallel to each other, the form of the section of the trunk or the anterior, posterior, and lateral profiles can be measured very rapidly. In order to determine the vertical section of the trunk, two rods bearing pins are attached to two vertical uprights; to obtain a horizontal section of the chest, four rods provided with pins and attached to a frame within which the subject of the experiment is placed, are employed. This frame may be adjusted vertically to any height desired.

Among other interesting data the Demeny conformator shows instantly, without requiring previous calculations, any


MOSSO'S ERGOGRAPH FOR MEASURING AND RECORDING FATIGUE OF THE FINGERS



TESTING STRENGTH OF THE ARMS WITH A BLOCH STHENOMETER



STUDYING MUSCULAR SENSE OF THE IDEA OF RESISTANCE

MEASURING STRENGTH OF THE LOINS WITH THE STHENOMETER

defect of symmetry in the structure of the body, such, for example, as a difference in height between the shoulders and hips or the ankles and the shoulder blades, as well as the normal or pathological curvature, as the case may be, of the spine, etc.

The Rachigraph or Profilograph.—This instrument which is especially designed to indicate the outline of the spinal column consists of a carriage movable in a vertical guide-way, by the side of which the patient stands, which bears a rod that is brought back to position by a spring and by a jointed parallelogram. In order to perform the experiment the observer after having placed the back of the subject against the vertical guide-way and attached a pencil to the end of the rod connected with the parallelogram, moves the carriage from bottom to top; this causes the curve of the spine to be recorded in life size dimensions upon the sheet of paper.

Another apparatus makes records of sections of the body taken in a vertical plane. The subject is held in a rigid position by means of a system of solid supports, while two rods mounted upon rollers outline the depth of his body, the record being inscribed upon a sheet of paper.

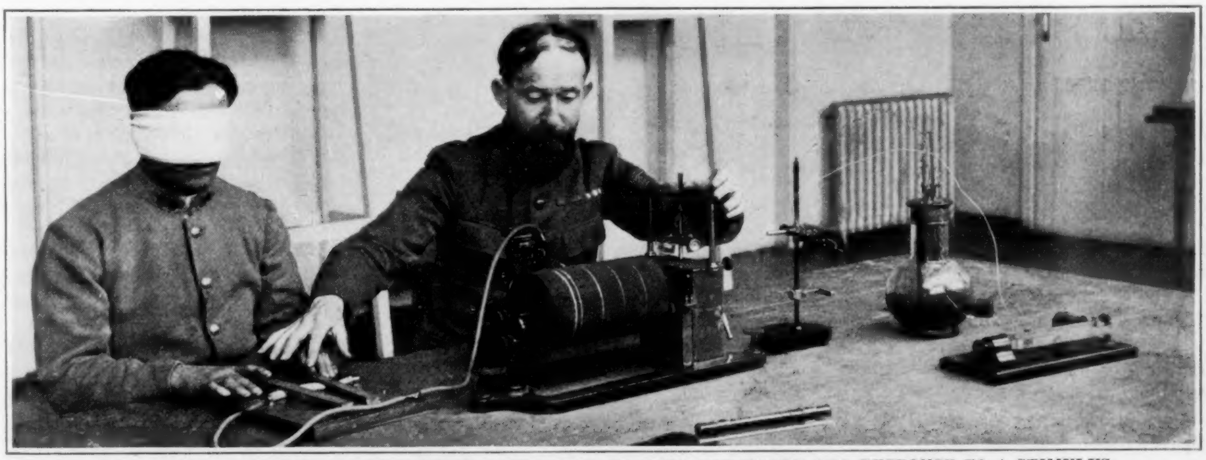
Spirometer.—To discover the volume of air taken into the lungs during a deep inspiration, a very simple spirometer is used at Joinville. It consists of a bell-glass balanced by a counter-weight and immersed in a cylinder three quarters full of water. The subject exhales the air through a rubber tube with a glass mouthpiece, which runs to the lower tubulure of the spirometic vessel. The section of this tube is exactly equal to that of the trachea so that there will be no resistance to the air proceeding from the lungs of the subject and no alteration of the respiratory rhythm. The air exhaled causes the internal pressure to be increased and the amount of the increase is shown by a manometer. Furthermore, if care is taken to graduate the manometer beforehand by injecting successively 1, 2, 3, 4, 5, etc., liters of air and marking the corresponding level of the water for each, the volume of air injected can be read off at once. An improved apparatus known as the *Verdin spirometer* is also employed. As shown in the photograph this apparatus resembles our familiar gas meter.

The Mosso Ergograph.—This instrument which is too well known to require description is employed to record variations in muscular work performed.

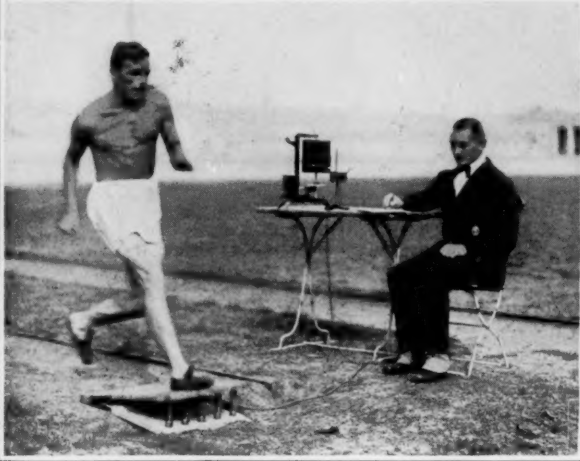
The Bloch's Sthenometer.—By means of this apparatus the strength of the loins and of the arms is readily found.

Chronophotography.—The mechanism of the movements made by muscles in action is studied by means of ordinary photography and motion pictures, and in more detail by chronophotography. An extended account of this latter process, especially as applied to the movements of men crippled in the war, was published in this magazine in the issue of January, 1920. Its value consists, of course, in the fact that it enables the physical instructor in charge to study the physiological effect of various exercises upon men with artificial limbs.

The Time Required for Response to a Stimulus.—One of Dr. Boigey's valuable inventions is a device similar to the



DR. BOIGEY'S METHOD OF DETERMINING THE TIME INTERVAL REQUIRED FOR RESPONSE TO A STIMULUS



MEASURING PRESSURES AT THE TAKE-OFF OF A RUNNING LONG JUMP

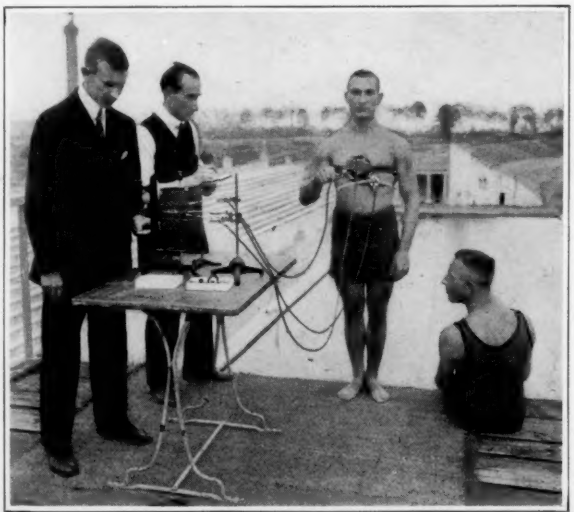
A GERMAN ATHLETE BEING SUBJECTED TO A SIMPLE FATIGUE TEST

Arsonval apparatus for measuring psycho-motor reactions. It is employed for measuring the interval of time required for response to any stimulus. The examiner touches the index finger of the subject's left hand with one of his own fingers and the subject responds with the forefinger of his right hand. He does this by placing each of his two forefingers upon wooden keys which press upon a rubber tube connected with a Marey recording cylinder.

The Study of the Muscular Sense.—To study the muscular sense Dr. Boigey proceeds from two starting points—the idea of *resistance* and the idea of *position.* In the first case the subject, whose eyes are bandaged, is seated at a short distance from the examining physiologist, who attaches to his index finger a thread or wire to which is fastened a weight of from 200 to 500 grams; to this he adds smaller copper weights of 10 or 15 grams each. The subject is required to estimate the amount of weight added or subtracted. If he makes a mistake this indicates either fatigue or neuro-motor disturbances.

In order to test the muscular sense by means of a change of position Dr. Boigey has prepared a wall chart upon which are drawn lines radiating from a common center and with their ends terminating at intervals of 15 centimeters. The subject, whose eyes are again bandaged, is placed so that his shoulder corresponds approximately to the center from which the radiating lines start; the examiner then lifts the arm of the subject to a given initial position which he marks with his hand. He next orders the subject to lower his arm to his thigh and then return it to its former position. In practice the subject most often brings his arm to rest 10 or 15 centimeters short of its initial position. (See frontispiece.)

Similar tests are being applied in German schools and we include among our illustrations three obtained from such an institution. In one the subject, who is clad in a bathing suit, is shown undergoing examination for nervousness or dizziness. He is required to stand at the edge of a platform about 12 feet above a swimming pool. Time curves are obtained which give an excellent idea of the character of the respiration and of the pulse and heart beat besides indicating indirectly the nervous condition and the morale with respect to courage and daring.



TESTING A SUBJECT FOR NERVOUSNESS OR DIZZINESS

Another picture shows a scientific examination of a running long jump. The pressure produced by the act of jumping off is indicated by curves which are afterwards critically compared so as to enable students to correct the faults revealed by the apparatus.

Still another picture also taken at what is ambitiously called "the world's first high school of physical culture," shows a simple fatigue test being given by the director of the psychological laboratories.

THE EBULLIOSCOPE AND THE CRYOSCOPE

AT a meeting of the New York Section of the American Chemical Society held on June 11th, two pieces of apparatus were exhibited which attracted much attention from the audience. The first of these is an improved apparatus for determining the amount of alcohol in "temperance" drinks and beverages made from cereals. This device is known as the ebullioscope because the method employed depends upon an accurate determination of the boiling point of liquids. Complicated forms of this have long been used but the present type is an improvement meant chiefly for the use of brewers producing malt drinks containing less than one-half of one per cent of alcohol. It has been found useful by inspectors of the Revenue Bureau in field work whenever quick tests, requiring not more than a quarter of an hour, are thought sufficient.

The cryoscope depends upon the opposite principle of a determination of the freezing point. It is a well-known fact that various liquids have various densities at the freezing point. For example, if milk has been watered the temperature at which it freezes is different from that at which pure milk freezes, and this difference is registered by the cryoscope. This instrument was developed by Dr. Hortvet of the Minnesota State Dairy and Food Commission.

Is Oxygen Necessary for Animal Existence?*

Formation of Carbon-Dioxide Only One of a Number of Possible Energy Producing Processes

By Dr. O. Krummacher

SINCE Lavoisier recognized the fact that the decomposition which takes place in the bodies of animals must be regarded as a process of combustion, the view has been held until quite recently, at any rate, that oxygen is indispensable to life. It is the object of the following article to discuss the extent to which this theory still holds good, and what modifications it may be subject to.

Lavoisier believed the lungs to be the hearthstone of the body upon which the combustion of fuel takes place. He held the view that the oxygen drawn into the lungs at once liberates its energy at this very spot. It was not till some time later that we learned that the pulmonary artery, the blood vessel which carries the blood to the lungs, already contains large quantities of carbon-dioxide, and that consequently this gas is not first produced in the lungs. It can also be demonstrated that the oxygen which is breathed in is not consumed in the lungs, since the pulmonary veins which carry the blood away from the lungs actually contain larger quantities of oxygen than do the pulmonary arteries. The blood, therefore, absorbs oxygen during its passage through the lungs, while as it flows through the rest of the body it becomes steadily poorer in oxygen and richer in carbon-dioxide. Somewhere in the organism, therefore, carbon must undergo combustion to form carbon-dioxide, *but just where does this occur?* It is natural to assume that the processes of combustion take place in the blood, but this concept was bitterly opposed in his day by the distinguished physiologist, Carl Ludwig.

But Ludwig was lacking in a faculty for comparative investigation. He once remarked to his pupil, Gaule: "When a man has once located himself comfortably on his own floor of the building, what does it matter to him what goes on in the lower stories." Of course, such a sagacious limitation as these words imply, may be quite in place as regards certain special problems, but when we are concerned with the most important characteristic of life, that of metabolism, we dare not close our eyes to those organisms which are lower in the scale than ourselves. The imperativeness of this view has been emphasized by no one more strongly than by Pflüger. In a noteworthy memoir, published in 1874, he collated the most important reason for the view that the physiological combustion does not take place in the fluids of the body, in the blood and the lymph, but in the tissues, in the cells and collections of cells, i.e., in the muscles, glands, and nerves. It will suffice in this place to cite the most striking bases of his views.

Lower Animals.—Many of the lower animals, which have been proved indisputably to form carbon-dioxide, have, in general, no blood at all, while in others, as in the insects, the function of the blood appears to be merely the conveyance of nutrition without any connection with respiration. It is far oftener the case among these that the entire body is penetrated by a system of delicate air tubes, whose most minute branches *directly penetrate the cells.*

Vertebrates.—And even among vertebrate animals physiological combustion is not indispensably associated with the presence of the blood: thus in the frog the blood may be replaced by a dilute solution of ordinary cooking salt without the formation of carbon-dioxide being diminished thereby. Finally, it can also be demonstrated that organs which have been separated from the body consume oxygen and form carbon-dioxide, although they are no longer supplied with blood, this being the case, especially in excised frog muscles. These instances, to which many more might be added, may have an application; this much, at any rate, is undoubtedly true—the seat of physiological combustion is to be found, not in the blood, but in the tissues.

On the other hand, it is a proved fact that the living body has no available energy except that of chemical tension; still, it by no means follows from this that the processes which liberate vital energy must necessarily be combustion processes.

Is Oxygen Indispensable to Life?—The question at once arises, therefore, as to whether oxygen is absolutely necessary to vital existence. The indispensability of this element was long considered a definitely proved fact, until investigators first came across *living organisms in the form of yeast cells, which flourish even when entirely deprived of oxygen.* It was learned later that there are numberless other bacteria which not only dispense with oxygen, but to whom oxygen is actually fatal. We are, to be sure, concerned here with very lowly organisms, which originally were numbered among the plants; but gradually similar observations with regard to animals were made in increasing numbers. Pflüger demonstrated that frogs are capable of living as much as 17 hours in pure nitrogen and that during the first 6 hours the formation of carbon-dioxide was hardly diminished. However, it must be admitted that they finally perished through the lack of oxygen. On the other hand, the worms which live in the intestines of many mammals have in general no need of oxygen, the animal of this sort most adapted for experiment is the ordinary abdominal round worm, *Ascaris.* After Bunge had first become convinced that these worms liberate carbon-dioxide which certainly is not formed by combustion, Weinland succeeded in determining their metabolism with more precision. These creatures derive the greater part of their energy from glycogen, which is usually found stored up in their bodies in large quantities. Through the operation of their vital activities this nitrogen is decomposed into carbon-dioxide and some of the lower fatty acids, chiefly valerian acids. The whole process presents great similarity to that of alcoholic fermentation, which likewise takes place without the aid of atmospheric oxygen. I have employed myself, together with Dr. Schulte, in the endeavor to explain this interesting process with respect to its phenomena of energy, but in the present article I shall refrain from going into details with respect to these experiments.

Life Without Oxygen.—It is thus demonstrated to be a fact that vital activity without oxygen is entirely possible, not only in one-celled organisms but also in animals with well-developed systems of muscles and nerves; and this is true, not merely as an exceptional instance, in the laboratory of the physiologist, but also under entirely natural conditions. It is, of course, a deeply rooted principle in human nature to hang on to old beliefs as long as possible. And when a thing which according to theory is quite inadmissible, cannot be explained, the first endeavor of mankind to find a path around the obstacle is to declare it to be a latent phenomenon.

Thus, there developed the hypothesis of the storing up of oxygen in a concealed or latent form, whose principle features were announced by Engelmann as early as 1868, upon the basis of his studies of the ciliated cells of lower animals, but which did not obtain its final form until stated by M. Verworn and his disciples.

According to this concept oxygen first meets with a nitrogenous compound of the living tissue. And from this compound, the *biogen,* there is then split off only the precise amount of oxygen required for the needs of the moment, thus a temporary life without any supply of oxygen is quite compre-

*Translated for the *Scientific American Monthly* from *Die Umshau* (Frankfurt) for September 18, 1920.

hensible, but not a continued life such as we find in intestinal parasites. It should be noted, however, that at the time when Verworn announced his *biogen theory* the peculiar conditions which characterize the life of the animals which dwell in the intestines had been subjected to scarcely any research.

But it may be asked whether the oxygen which is a component of carbohydrates, fats or albumins might not take over the rôle of atmospheric oxygen. When in the process of fermentation grape sugar is decomposed into alcohol and carbon-dioxide, it is acknowledged that the oxygen held fast in the carbon dioxide is derived from the grape sugar, and yet in this case also the carbon-dioxide is transformed into the highest stage of oxidation, so that the expression has been applied to it of intramolecular oxidation. The case is quite similar with the above-mentioned splitting off of carbon dioxide from the glycogen in the body of the *Ascaris*. Whereas, therefore, in the earlier views of the matter oxygen was considered unconditionally requisite for this vital process, but according to the newest investigations can be dispensed with, yet men of science have sought to reconcile these opposite views by the doctrine of *intra-molecular oxidation.*

Intra-molecular Oxidation.—At present the term *Intramolecular respiration* is commonly used instead of the above expression, especially among botanists, who, in contradiction to students of animal physiology, signify by the word respiration not only the exchange of gases which takes place in the body, but also those combustion processes which take place in the living organism. However, this attempt to reconcile these contrary ideas hardly bears the test of a closer examination. It is by no means true in general that when atmospheric oxygen is lacking, carbon-dioxide is nevertheless produced. There are, indeed, certain living organisms, such as a certain kind of lactic bacteria, which as a general thing do not form carbon-dioxide, but exist rather by means of that energy which is liberated from the grape sugar in lactic acid, according to the terms of the following equation:

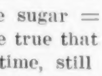
$$C_6H_{12}O_6 = 2C_3H_6O_3$$

or one molecule of grape sugar = two melecules of lactic acid. And while it may be true that other metabolic processes take place at the same time, still it has been indisputably demonstrated that carbon-dioxide is never produced by this sort of bacteria.

It should be recalled further that carbon-dioxide is not the only element which plays a part in the liberation of energy: We need only call to mind the *sulfur bacteria* whose need of calories is supplied essentially by the combustion of sulfuretted hydrogen. The foregoing considerations indicate that the *formation of carbon-dioxide from carbon is only one among a number of possible processes for the creation of energy in the living organism and is by no means an essential characteristic of life.*

If we acknowledge this to be true and consequently refuse to accord to carbon-dioxide a peculiarly privileged position above that of other elements in the great household of living organisms, then it is obviously without any special significance to make a point of talking of intra-molecular oxidation in the splitting off of carbon-dioxide from the organic molecule; for if the oxygen changes its position within the molecule, then naturally the oxidation of the one group must go hand in hand with the reduction of another group, as may be readily seen by the following example:

Ortho-nitro-benz-aldehyde is transformed under the influence of light into nitroso-benzoë-acid according to the following formula:



in which the aldehyde group is oxidized and the nitro group reduced.

This connection is, it must be confessed, not so readily obvious in the phenomena of fermentation; the butyric acid fermentation alone affords a striking example, in that carbon-dioxide is produced upon the one hand and free nitrogen on the other. It is my opinion, therefore, that we are justified in accepting the following hypothesis:

Those processes of the living organism which are concerned in the expenditure of energy are so manifold that we are unjustified in accepting any preconceived limitation with regard to the processes which characterize them. There is only one condition which must inevitably be met with under all conditions, namely, *that in all chemical processes taken as a whole, the energy must diminish in order that the organism may profit by the energy liberated in the form of heat and of work done.*

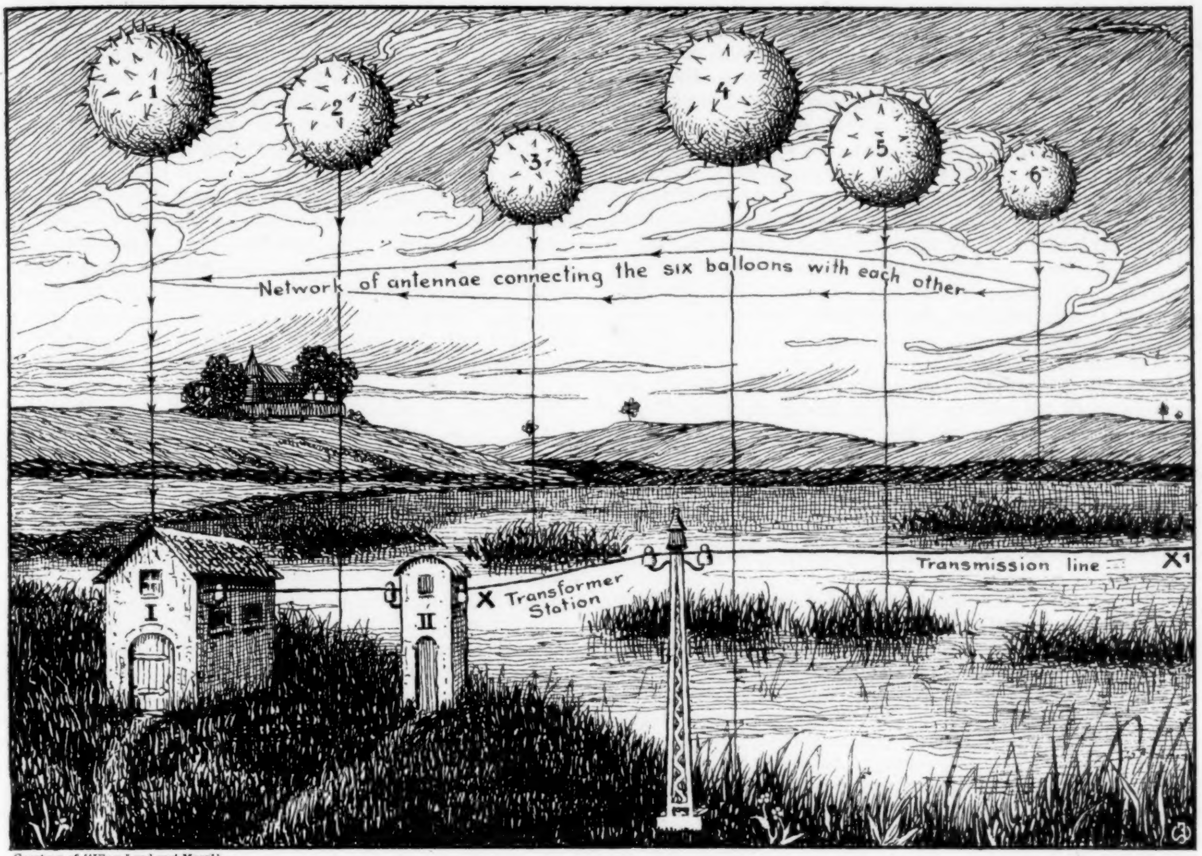
On the other hand, the coöperation of oxygen is not universally demanded by the living organism, just as economically we are by no means obliged to produce chemical energy by combustion. To build a gas motor which would burn hydrogen and chlorine would offer no insuperable difficulties to our engineers, but the thing would be absurd since the chemical energy of oxygen is everywhere available for nothing. (In connection with a lecture given upon the same subject before the *Medizin-Naturwissen.* Society at Münster i. W. Privy Counsellor Kassner called atention to the fact that gas motors of the kind just mentioned are actually in use at the present time, being employed, however, not to yield energy but to produce hydro-chloric acid).

In conclusion, we may remark, however, that the higher animals have learned to make use of the readily available chemical energy of the oxygen which is found everywhere upon our earth. And for this reason alone they are able to obtain a greater yield of work done and of heat than will be possible for them to obtain from a life without oxygen.

DO MIGRATORY BIRDS MAKE PREPARATION FOR THEIR FLIGHT?

A GERMAN professor, Dr. Thienemann, has recently raised the interesting question as to whether birds which change their place of abode in spring and fall prepare themselves previously for long journeys. Such a preparation might conceivably consist of two kinds. It might, on the one hand, include the swallowing of a definite amount of food and, on the other hand, it might consist of some modification in the character of the plumage. In other words do the birds fly with full crops from which to obtain the necessary energy for their muscular effort, or do they, on the other hand, fly with empty crop and stomach in order to lessen their weight? Furthermore, is there any difference in plumage observable just before the start?

In order to solve the first question the learned professor first experimented with caged birds in order to see how much time they required after the taking of food for the crop and stomach to become entirely empty. He found that after feeding plentifully, in the majority of cases no trace of food was left at the end of four hours, in a smaller number eight hours was required. He then examined birds captured in the act of migration. In these he found that out of 183 individuals 18 per cent had the crop and stomach full, 40 per cent had it empty and 42 per cent had it moderately filled. The majority, therefore, appeared to endeavor not to overload the stomach. The migratory instinct prevails in general over the hunger instinct. As to the second question, whether migratory birds exhibit any special care as to keeping their plumage in good condition, he believes that the birds will not refrain from migrating because of injury to the plumage or disorder in it. His observations seem to prove that the dominant instinct in migrating birds is the attempt to proceed. The stimulus which causes them to seek food is practically excluded during the time of the strongest migratory impulse, so that at times the birds appear almost entirely indifferent even to their favorite delicacies; thus the falcon migrates close beside the dove without injury to the latter.



Courtesy of "Uber Land und Meer"

PLAUSON'S PROPOSED BALLOON PLANT FOR COLLECTING AND UTILIZING ATMOSPHERIC ELECTRICITY

The electricity is periodically discharged, producing a high frequency current which flows from the collecting station I through the transformer X to the transmission line.

Capturing Electricity from the Air

Recent Studies Regarding Atmospheric Electricity and Its Possible Utilization

By T. A. Marchmay

OLD KING COAL has served mankind well but at the present hour his services are coming uncommonly high. Small wonder then that our inventors and men of science are becoming increasingly keen in their endeavors to find some source of energy which may replace, at some future day, if not in the immediate present, those stores of fossil sunlight, which within but little more than a century have revolutionized human activities and made modern actualities of Arabian Nights dreams.

One of the newest propositions of this sort, which is attracting widespread interest on the continent of Europe, where the pinch of fuel shortage is even more keenly felt than in our own richer country, is the suggestion to make use of what is believed to be the inexhaustible storehouse of static electricity contained in the upper reaches of our atmosphere. In normal weather the terrestrial atmosphere constitutes a practically uniform electric field in which the surfaces of equal potential are parallel to the earth and the lines of force are vertical. The degree of the potential increases with comparative regularity—except during periods of violent atmospheric disturbance—in proportion to the distance above the level of the ground. This difference of potential varies also according to the season of the year, being estimated at 100 volts per meter during the summer, on an average, and 300 volts during the winter. A Hamburg scientist named Plauson, who has been studying this subject for a number of years, has proposed an ingenious scheme by means of which this energy of the upper air may be captured and set to work. He has already demonstrated, in fact, that at altitudes exceeding 300 meters it is possible to capture an average of 200 horse-power per square meter; his latest experiments, indeed, have yielded as much as 400 to 500 horse-power.

He proposes to make use of a system of huge balloons having a metallic surface and connected with each other by an aerial network of conducting wires. These balloons act as collecting antennae and, that they may the better fulfil this function, they bristle with a series of points as shown in the accompanying illustration, so that they somewhat comically resemble those queer puffer fish which can inflate themselves like rubber balloons, and which likewise bristle with sharp points. Further to increase their power of capturing energy he proposes to impart conducting power to the air by ionization, and he proposes to secure this by means of radio-active salts such as radium, polonium, etc., placed at the extremities of the antennae. Each system of balloons is connected with the earth by means of non-conductors, and the vast supplies of energy thus collected in the upper strata of the air are discharged at brief intervals so as to produce a high frequency current.

This current can be utilized immediately in the preparation

of nitric acid and ozone from the air; hence if it proves practical mankind's other fear of exhausted fertility of the soil will be set at rest. By making use of suitable transformers the aforesaid current can also be employed in electro-chemistry and electro-metallurgy. A well-known French writer, M. Matignon, writing upon this subject in *Chimie Industrie* (Paris) for April, 1920, states that it is possible to produce 5 tons of carbide in 24 hours by means of the power thus captured upon a surface of 6 sq. km. Other interesting figures given by M. Matignon are found in his estimate that assuming an attainable power of 100 hp. per kilometer, the total surface of France would yield 100 million horse-power. A German writer, Fredrich Otto, writing in *Ueber Land und Meer* (Berlin) for October 31, 1920, estimates similarly that an area equal to the surface of Germany would yield 720 million hp. per day.

It would obviously be impossible, however, to devote the entire area of the country to the anchoring of flocks of huge balloons. Herr Plauson proposes to employ as locations for collecting stations such barren localities as seas and lakes, heaths, moors, deserts, steppes, mountainous areas, etc. He estimates that about one-third of the surface of Germany could thus be employed for the collecting of atmospheric electricity without interfering in the slightest degree with agricultural interests.

But what would be the expense if this grandiose enterprise were to be carried out upon the scale which its inventor enthusiastically hopes for. Herr Plauson admits that the initial cost would undoubtedly be very great, and yet he does not hesitate to assert that this aerial electrical current would be in the long run, and all things considered, considerably cheaper than that obtained from coal. He expresses the hope that the enterprise may be taken up by the government, the first steps, of course, to consist in the erection and establishing of suitable experiment stations. Such a station is shown in the picture which accompanies the text, and which was drawn by W. Jacobs.

It must be admitted that there are certain hard-headed men of affairs who fail to share the inventor's enthusiasm concerning this novel idea, but as Herr Otto justly points out incredulity has been the common fate which has attended novel ideas throughout the course of human history. Even in the early part of the present century many wiseacres considered Count Zeppelin's plans for huge dirigibles merely a colossal joke. Galvani, whose name is enshrined among the potent terms of electricity, wrote sadly in 1792, "I am attacked by two sets of men—by the wise men and by the fools." Philippe Lebon, who discovered the process of illumination by gas, was considered a perfect fool for believing that any light could burn without a wick. The Royal Medical College of Bavaria solemnly declared that steam engines and railroads constituted a crime against the public health. But it is needless to cite further examples of the obstinate conservatism of the human mind with regard to new ideas. Let us turn rather, for further light upon the potentialities of this vast project, to a consideration of the recent researches by other investigators in the fascinating field of the nature and origin of atmospheric electricity.

NATURE AND ORIGIN OF ATMOSPHERIC ELECTRICITY

Many men in many lands have followed the clue given by Franklin in 1752, with regard to the character of the mysterious and terrifying phenomenon of lightning, whose power to impress the imagination of man is borne witness to, alike in the folk lore of the savage and the loftiest literature of civilized races. Among these we may mention among the moderns Becquerel, Lord Kelvin, Peltier, Pellat, Saussure, and more recently, since the theories of ionization and of radioactivity have given a new slant to the subject, Eve, Simpson, Wilson, Birkeland, Ide, and Swann. The last named authority has been studying this subject for more than fifteen years, with all the advantage of the most admirable equipment. He has conducted his studies, both by land and by sea, in the latter case upon the boats *Galileo* and *Carnegie*, belonging to the Carnegie Institution.

In giving an account of Mr. Swann's remarkable observations in this domain, for information concerning which we are indebted to an article recently published by the *Journal of the Franklin Institute*, it is advisable, perhaps, though at the risk of some repetition, to give a brief résumé of the knowledge possessed on the subject.

The ground is not an electrically neutral body. Its surface may be considered to be covered with a layer of negative electricity and this gives birth in the atmosphere to an electrical field of considerable importance. As we have said in the earlier part of this article the difference of potential increases with the altitude; this increase is at the rate of about 150 volts per meter. This is known as the *gradient of the potential*, and is the subject of regular measurements in all observatories.

Variations of potential in the atmosphere.—Save in exceptional cases the gradient of the potential always takes the direction which results from the existence of a negative charge upon the ground. But this is not an invariable quantity; it undergoes both daily and annual variations, and is always higher in winter than in summer. As stated above the gradient decreases in proportion to the altitude. Observations have been made by means of sounding balloons up to a height of 9 km. at which level the gradient is only 2 volts per meter instead of 150, as upon the ground.

The existence of the gradient and its gradual diminution up to a height of 10 km., may be explained by assuming that this atmospheric stratum, 10 km. in thickness, contains a positive charge, which is exactly equal to the negative charge spread over the surface of the earth. Experiment has shown the existence of this positive charge, in fact.

If the atmosphere formed a perfect insulator the system constituted by a negative electric charge upon the surface of the ground and a positive charge in the surrounding atmosphere, might continue indefinitely. But this is not the case. While it is true that the electrical conductivity of the air is extremely feeble, it would, nevertheless, be sufficient to occasion in less than 10 minutes a discharge of 90 per cent of the electric charge of the ground, were it not reconstituted in some manner. It is the method by which this charge is constantly reconstituted, which has long proved a puzzle to students of electric phenomena.

The conductivity of the atmosphere.—This conductivity, compared to that of a metallic substance, like copper for example, is extraordinarily weak. Mr. Swann calculates that a column of air 1 centimeter in length offers to the passage of the current the same resistance as a copper cable of the same section, and of a length of 15 billions of millions of kilometers, that is to say, 8 times as long as the distance from the earth to Arcturus and back.

But no matter how feeble it may be the conductivity of the air is by no means nil, and modern theories of electricity are quite capable of explaining the mechanism thereof. According to these theories matter is composed mainly, if not exclusively, of positive and negative electrical particles, the latter, the electrons, carry the same charge and are the same as to dimensions and as to mass. Certain agents are capable of separating an electron from the molecule, which thereupon appears to be charged with positive electricity and constitutes the positive ion. The electron is capable of traveling a certain distance in freedom, but sooner or later attaches itself to a neutral molecule or group of molecules to form a negative ion.

It is these ions which render the air a conductor. Under the influence of an electrical field, the positive and negative ions move in opposite directions, some toward the negatively charged body and the others toward the positively charged body and become discharged. But let us suppose that some permanent source of ions exists in the atmosphere. The number of ions contained per cubic meter of air would con-

stantly increase, unless the negative and positive corpuscles tended to recombine because of their mutual attraction; the more numerous they are the more rapid this combination. We must assume, therefore, that an equilibrium is established between the number of ions produced and the number which are recombined: thus, it is supposed that six pairs of ions are produced in the atmosphere per second per cubic meter. When the number of pairs of ions per cubic meter reaches 2,400 it is found that six pairs of ions recombine in one second; at this moment equilibrium is attained and the number of ions can no longer increase.

The origin of atmospheric ions. Swann attributes the continuous production of ions in the atmosphere to two causes:

1. *Radio-active emanations* in the air;
2. The so-called *"Penetrating radiation."*

All of these radiations possess the power of ionizing either directly or indirectly any gas through which they may pass; the *alpha* particles being especially efficient so that they expend all their available energy in the process and come to rest after passing through only a few centimeters of air. The *beta* particles are much less efficient and may travel several meters before coming to rest. The *gamma* rays are still more penetrating and less efficient as ionizers, so that after passing through 100 meters of air they still retain 36 per cent of their initial value. Mr. Swann thus elaborates these ideas in an article presented by him originally at a joint meeting of the electrical section and the Philadelphia section of the American Institute of Electrical Engineers, held November 1, 1917. At the time this lecture was given Mr. Swann, who is now professor of physics at the University of Minnesota, was chief of the Physical Division in the Department of Terrestrial Magnetism in the Carnegie Institution at Washington. The following excerpts are taken from the paper as published in the *Journal of the Franklin Institute*, for November, 1919.

Now the soil contains radium and other substances of this nature, and these give rise to active gaseous emanations which diffuse out into the atmosphere. During the disintegration of these emanations in the atmosphere, α, β and γ rays are emitted with the result that the air becomes ionized and is rendered conducting. The amount of radium emantion in the atmosphere varies very much from time to time. It is, however, always extremely small. In a shell of the atmosphere extending over the whole of the earth's surface and comprised between that surface and an altitude of one kilometer, we shall find only about 250 grammes of radium emanation. Or, expressing this magnitude in another form, we may say that each cubic centimeter of the atmosphere contains on the average only between one and two molecules of radium emanation, as compared with the thirty million million million molecules of air which it holds. Nevertheless, by adding up the ionization produced by the α, β and γ rays from the emanation and its products we are able to account for the production of 1.7 ions per second in each cubic centimeter of the atmosphere. In addition to radium emanation, another radio-active gas, thorium emanation, is also found in the atmosphere and contributes to the ionization. Again, a certain amount of atmospheric ionization is attributable to the radio-active materials in the soil. Here we are only concerned with the γ ray ionization, since α and β rays are so readily absorbed that they never succeed in getting out of the soil. The soil contains, on an average, about 4×10^{-12} gramme of radium per cc., and, by calculating the amount of γ radiation which can be accounted for, after allowing for the absorption of the rays coming from different depths in the soil, we find enough to provide for the production of 0.80 ions per cc. per second. In a similar way, the thorium in the soil is found to be capable of accounting for a rate of production of 0.80 ion per cc. per second.

These results on the amount of ionization which the radioactive material is capable of accounting for are summarized in a table prepared by A. S. Eve; and it appears that, altogether, a rate of production of 4.35 ions per cc. per second can be accounted for in this way. From a knowledge of the rate at which ions recombine we can calculate the number to which they would build up in the atmosphere on account of a rate of production of 4.35 ions per cc. per second, and the result comes out to 1,320 ions of each sign per cc.

Measurements of the numbers of ions per cc. in the atmosphere are attended with considerable difficulty, for all sorts of different types are present. In particular, there is a class of ion which is very sluggish in its motion, and which is probably nothing more than an ordinary ion which has attached itself to a dust particle. On account of their sluggishness, these ions contribute very little to the conductivity, but they nevertheless influence the requirements in the matter of the rate of production of ions; for they contribute to the rate at which the ions recombine. It has been customary to measure the numbers of ions per cc. by a method which takes account of the most mobile ions only, and it appears that about 800 pairs of these exist per cc. Thus, quite apart from the direct evidence of the existence of the sluggish ions, we may conclude that ions of this type must be present, since the radioactive material in the air and soil is alone capable of accounting for 1,320 ions per cc.

The uncertainty of our knowledge of the true average values for the total numbers of ions of all kinds, and of the appropriate rates of recombination, prevents us from doing more than to say that, as far as measurements on land are concerned, the radio-active material in the air and earth is sufficient to account for the whole of the ionization produced. A difficulty presents itself, however, when we consider the results of observations made over the sea. Those who have made observations over the ocean have found very little radioactive material. Some of the most recent observations have been made on the yacht *Carnegie*, owned by the Carnegie Institution of Washington; and, as a result of observations extending over about 30,000 miles in the Pacific and Sub-Antarctic Oceans, an average radio-active content was found, for the atmosphere, amounting to only 2.6 per cent of that found on land, and the radio-active content of the sea water collected in regions remote from land was immeasurably small. Nevertheless, the number of the more mobile ions found per cc. over the ocean is as great or greater than that found over land, as shown in a table which represents a comparison of the results of the *Carnegie's* fourth cruise with those obtained by other observers at sea, and with land values. The number of ions is much larger than can be accounted for by the small quantity of radio-active material in the ocean air.

What, then, is the agency responsible for the ionization over the ocean? It appears to be the so-called "penetrating radiation." If a hermetically sealed vessel is freed from radioactive air, we nevertheless find that ions are produced in it at a fairly constant rate of about 10 ions per cc. per second over the land. An appreciable proportion of this ionization is due to the α ray radiation which comes from the soil and passes through the walls of the vessel. That the whole of it is not due to this cause is, howsver, borne out by several circumstances. In the first place, ionization in closed vessels is found to take place over the ocean, where there is practically no radio-active material, and it there amounts to about 4 ions per cc. per second in a copper or a zinc vessel. Scondly, if, in experiments on land, the apparatus is surrounded by a wall of water of sufficient thickness to shield off practically completely the α ray radiation from the earth, there still remains a rate of production of about 4 ions per cc. per second. But *strongest evidence of the reality of the penetrating radiation* is to be found in the results obtained in balloon ascents by W. Kolhörster. It appears that, with increase of the altitude, the ionization within a closed vessel at first diminishes up to an altitude of 700 meters. This we should expect as a result of the absorption of the earth's γ ray radiation by the atmosphere. Above this altitude an astonishing thing happens, however. The ionization commences to in-

crease, and goes on increasing with greater and greater rapidity until, at an altitude of 9,000 meters, the intensity of ionization is in excess of that at the earth's surface by about 80 ions per cc. per second. An increase of 20 ions per cc. per second takes place in the last kilometer, and the rapidity of the increase at these higher altitudes is such as to suggest that very large values of the ionization would be obtained at altitudes not very much greater.

It thus appears that there is some source of ionization other than the radio-active materials in the soil and lower atmosphere; and this agency, whatever its origin, appears to be the sole source of ionization over the ocean. The rate of production of ions must certainly be greater over the land than over the ocean by the amount attributable to the radioactive materials on land. It is probable, however, that over the land, where dust nuclei are more plentiful than over the ocean, a much larger proportion of the ions produced join the slowly moving class than in the case with the ions produced over the ocean; and it is to this cause that we must attribute the fact that the ionic density for the more mobile ions is no greater over the land than over the sea.

To return to the remarkable increase with altitude shown by the ionization within closed vessels. Such a variation at once suggests a radiation coming from some source external to our globe, or from some active agency in the upper regions of the atmosphere, the decrease in intensity encountered as we *descend* into the atmosphere being accounted for by absorption. The rapidity of the absorption can be calculated from the observations on the variation of intensity with altitude; and it appears that the observations require us to assume for the radiation a penetrating power ten times that of the most penetrating γ rays known in radio-active substances. We must not be too skeptical as to the possibility of the existence of so penetrating a radiation, for light itself is extremely penetrating as regards air, since we can see the stars through the whole thickness of our atmosphere. The "penetrating radiation" is not light, however, for it can pass through the walls of a metal vessel. Its true origin remains one of the most interesting speculations of atmospheric electricity. Linke has suggested a layer of strongly radio-active cosmical dust in the atmosphere at an altitude of 20 kilometers. For my own part, it seems more natural to seek an explanation from another standpoint.

It is generally supposed that the Aurora is due to light generated by the impact, with our atmosphere, of negative electrons shot from the sun. The stream of electrons is not confined to the sunlit side of the earth, since the paths of the electrons are bent in passing through the earth's magnetic field, and some enter our atmosphere on the side remote from the sun. Now it is a well-established fact that when electrons strike molecules of matter X rays are produced. The greater the velocity of the electrons, the higher the penetrating power of the X rays produced. γ rays themselves are nothing more than a particularly penetrating type of X rays. Modern developments in our knowledge of X rays and γ rays have taught us how to calculate the velocity which an electron must have in order to produce γ roys of any given degree of penetration. Now, from considerations of the theory of the Aurora, into which time will not permit me to enter, Birkeland has shown that it is necessary to assume that the electrons which are responsible for this phenomenon have an energy enormously greater than that of even the swiftest β rays with which we are familiar in the laboratory; and, if we invoke the assistance of these high-speed electrons necessitated by the theory of the Aurora, we find that their speed is sufficiently great to account for the production of a γ ray radiation of a degree of penetration fully as great as that of the "penetrating radiation." The electrons themselves are not the "penetrating radiation" for, in spite of their great energy, they could not travel right through our atmosphere. By conversion of their energy into the γ rays, however, a radiation of much greater penetrating power is created.

The cause of thunderstorms.—In any discussion of atmospherical electricity, naturally, the origin of thunderstorms must take an important place. The most successful theory to afford a full explanation of these phenomena, is that suggested by G. C. Simpson, which has been further developed on the meteorological side by W. J. Humphreys.

The theory is founded on the experimental fact that if water is broken into drops by allowing it to fall upon a rising column of air, the drops are found to be positively charged while the air receives a negative charge. Now experiment has shown that it is impossible for drops of water to fall through air which is rising with a velocity greater than 8 meters per second. If the drops are very small they will be blown up by a rising column of air, and it is in general necessary for a drop to have a certain minimum mass before it can fall through a column of air rising with specified velocity. If the velocity is as high as 8 meters per second, however, the size which the drop would have to attain in order to fall through the column would be so great that the drop would be broken up by the air stream, even if it succeeded in attaining the necessary size temporarily. The smaller drops formed as a result of the disintegration would, of course, be carried upward by the air stream.

Now it is a matter of common experience that thunderstorms are always preceded by high winds, and a close examination of the phenomena shows that, in the storms which give rise to electrical discharges, columns of air are to be found rising with very considerable velocity. We may liken one of these columns of air to an hour-glass, or dice box. At the bottom the column is wide. At the narrowest part of the column the air attains its maximum velocity, while at the top it fans out and the velocity again becomes small. Now in the period prior to a thunderstorm, the air is very humid. As this air rises and becomes cooled in the process, it eventually reaches a temperature at which drops of water begin to condense out. At first, these drops are carried upward with the stream; but, as they grow, they eventually reach a size at which they start to fall. Suppose that when this occurs, the drops are some distance above the narrowest part of the air column. Then, as they fall and continue to grow in size they eventually reach a place where the velocity is sufficiently great to break them up. The smaller drops become positively charged in the process and the air receives a negative charge. The small drops now start their ascent again, although, of course, with velocity less than that of the air. As they rise they grow, and eventually the whole process is repeated again. The cycle may be gone through several times, the drops becoming charged more and more each time. The free negative ions which ascend with the rising air eventually coalesce with the finer water drops to be found at the top of the cloud, so that we eventually attain a state of affairs in which the water at the top of the cloud is highly charged negatively, while that in the middle of the cloud is highly charged positively. When the accumulations of charges are sufficient to result in a field which will break down the insulation of the air at some point a lightning flash follows. It thus appears that the high winds which are associated with the thunderstorm are in no sense a result of the electrical manifestations; the electrical phenomena are themselves secondary features resulting from the air motion.

During the turbulence associated with the storm, some of the large drops of positively charged rain which have gone through the cycle of breaking and reformation several times get carried to places where the velocity of the upward current is not sufficient to break them up, and they fall to earth. In this way we find the explanation of the experimental fact that the heavy rain of the thunderstorm is found to be positively charged. On the other hand, the rain which accumulates at the top of the cloud, and which is negatively charged is of the finer type, and may be expected to fall to earth only in the lulls between the periods of most violent activity, or at places somewhat remote from the storm center. Here, again, experiment sup-

ports the conclusions in showing that the finer rain which falls during the quiet periods of the storm is negatively charged.

HOW THE EARTH'S CHARGE IS MAINTAINED

Since the earth is constantly losing negative electricity because of the action of the potential-gradient operating in the conducting atmosphere, it is of importance to inquire how its charge is maintained. The current from a square centimeter of the earth's surface is only about 2 x 10^{-16} amperes. The current from the whole earth is only about 1,000 amperes, or about as much as is taken by 3,000 incandescent lamps. It is nevertheless sufficient to insure that 90 per cent of the earth's charge would disappear in ten minutes if there were no means of replenishing the loss. How then is the loss replenished?

One of the earliest suggestions was made by G. C. Simpson, who supposed tentatively, that the sun emitted positive and negative corpuscles of a very high penetrating power. He further supposed that the penetrating power of the negative corpuscles was greater than that of the positive corpuscles, and sufficient to enable them to reach the earth's surface, while the positive corpuscles were caught by the atmosphere. In this way the attempt was made to account for the negative charge of the earth and the positive charge of the atmosphere.

As a matter of fact, it is unnecessary to go to any special pains to account for the maintenance of the negative charge on the surface of the earth. For it is an experimental fact that the atmospheric conductivity increases with altitude until its value at an altitude of nine kilometers is about thirty times the value of the earth's surface. It follows from this that if the potential-gradient were the same at an altitude of nine kilometers as it is at the earth's surface, more negative electricity would be driven outward through a sphere at the altitude of nine kilometers and concentric with the earth than would be driven out of the earth's surface into the atmosphere. The shell of air below the altitude in question would consequently acquire a positive charge, so that the potential-gradient at the altitude of nine kilometers would become less than that at the earth's surface. The process would continue until the diminution of potential-gradient with altitude was just sufficient to compensate for the increase of conductivity with altitude so as to leave the conduction current-density independent of altitude.

The chief objection to Simpson's tentative theory, however, is one which he himself supports in a recent publication (*Some Problems of Atmospheric Electricity. Monthly Weather Review*, vol. xliv. pp. 115-122, 1916), viz., that it postulates a degree of penetration for the corpuscles so enormously great compared with any corpuscular penetration we have become acquainted with in the laboratory since the suggestion was put forward, that one hesitates to make this hypothesis without further evidence.

Other hypotheses have been formulated by various scientists, particularly the German, Elster and Geitel, and the English physicist C. T. R. Wilson. To go into these various theories would take us too far afield but that of Wilson is worth mention, because it is connected with his important discovery in regard to the part played by ions in the condensation of water vapor. His hypothesis is that the ions act as nuclei which promote the condensation of water vapor, and he observed that the vapor is condensed more readily upon the negative than on the positive ions. He, therefore, argued that rain should be on the average negatively charged. Swann, however, points out that unfortunately 75 per cent of the charge brought down by rain is of the positive sign; he, also, raises several other objections to this theory which he considers fatal.

PENETRATING RADIATION

Swann himself finds the explanation of the electric charge of the ground in *penetrating radiation*. The study of the γ rays has shown that the ionization occasioned by them consists of an emission of electrons projected in the direction of the incidental γ rays and which are themselves endowed with a power of penetration, whose degree varies in proportion to the penetrating power of the radiation to which they owe their origin. Hence, electrons produced by the ionization of an extremely penetrating radiation may travel a considerable distance before coming to rest.

Thus the successive strata of the atmosphere are traversed by electrons set free from the upper layers; these corpuscles in their turn come in violent contact with molecules of matter, thereby giving rise to a penetrating radiation which occasions the emission of new electrons directed toward the ground—and thus we come nearer and nearer to the ground, which finally receives the electrons sent forth in the layers of air in its immediate proximity. At every point of the atmosphere, therefore, we must suppose that there is a current of electrons passing from the top to the bottom and animated with great velocity by the penetrating radiation; and, likewise, that there is a conduction current moving in the opposite direction carrying the negative electricity of the ground to the atmosphere, so as to establish a state of equilibrium.

Mr. Swann's article also contains a section upon atmospheric-electric measurements, including that of the penetrating radiation, which is somewhat too technical to be included in this brief account of his valuable researches.

ELECTRICAL CONCENTRATOR IN SULPHURIC ACID MANUFACTURE

AN electrical concentrator has been installed by the Chemical Construction Company at Mount Holly, N. C., and has been operated intermittently for several months with good results. During 1918 a one-ton capacity unit was installed at a chemical plant at St. Albans, W. Va.

This concentrator is designed for small capacities where electrical current is available and comparatively cheap. It consists of a small bath space built of acid-proof masonry in which are placed two electrodes of acid-proof iron spaced about 2 or 3 feet apart, the electrodes being adjustable. The bath of acid is also so arranged that the level may be lowered or raised. There is a dam of acid-proof masonry between the electrodes. The weak acid is fed in at one end of the furnace near the electrode and flows over the dam to an outlet at the other end. The electric current between the electrodes passes through the thin layer of acid flowing over the dam and heats this thin layer to the point where the water is evaporated at a rapid rate.—A. E. Wells and D. E. Fogg, Manufacture of Sulphuric Acid in the United States; 1920 Bureau of Mines Bulletin, No. 184.

TRANSMISSION OF ELECTRICITY FROM NORWAY TO DENMARK AND SWEDEN

THE possibility and practicability of harnessing the waterfalls in southern Norway and distributing 3-phase current of 50 periods at a pressure of 220 kilovolts to southern Sweden by aerial lines and to Jutland through a 45-mile long cable across Kattegat from Gothenburg to the Skaw, is discussed by Eivind Hanssen in *Teknisk Ukeblad*, June 11, 1920.

Sealand and Copenhagen could be supplied by extending the overhead line south across the Sound by a cable three miles long near Elsinore. The total length of the aerial line will be not less than 500 miles. The author admits that the highest voltage at present in use is 155 kv., but is of the opinion that an increase to 220 kv. would not cause insurmountable difficulties. Two American lines, which work at a pressure of 155 kv., have been found quite satisfactory, and it has recently been proposed to transmit 1.5 million kw. at a pressure of 220 kv. in one of them. The Norwegian-Danish line would, as a first installment, carry 155,000 kw., there being no difficulty in selling this output in Denmark.—Abstracted by the *Technical Review*.

The Photo-Ratiograph*

A New Instrument for the Study of Vibrations

By A. C. Banfield

THE question of the interference of vibrations is one which has long commanded the close interest of scientific men, whether they are those met with in the study of light, electricity, heat or sound. In these cases the question of vibrational interference is of the greatest economic importance, affecting matters so remote from each other as the tone of a piano and transmission of electrical energy from one locality to another.

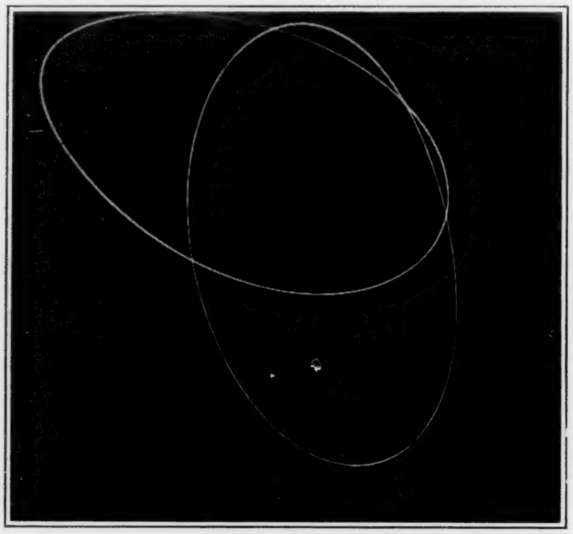
Quite another class of vibrational interference has long commanded a large amount of interest from two sets of people: the scientific dilettante, for the exquisite beauty of the resultant curves; and the mathematician, for the fundamental laws on which these beautiful curves are based. These curves are generally known as "harmonograph" drawings.

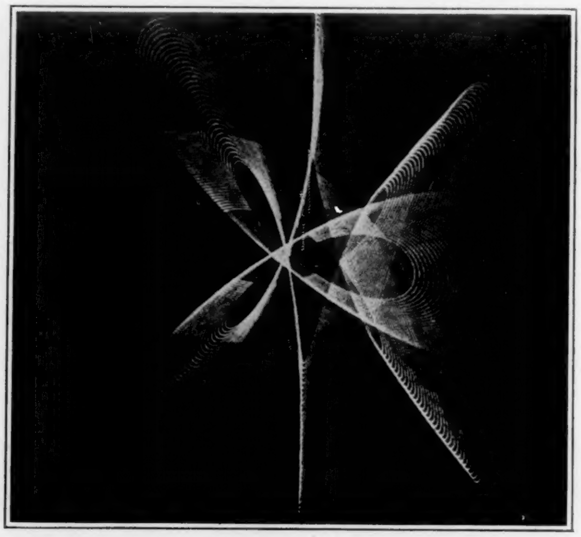
The harmonograph, generally speaking, is somewhat tolerantly regarded in physical circles as a scientific toy, though the beauty of the result never fails to excite admiration, grudging though it may be. The cause of this attitude probably lies in the fact that science always deals with exact premises, and in this the usual pendulum-controlled harmonograph fails lamentably. It is impossible to state definitely, for example, exactly the path which the pendulums are describing—it may be anything from a straight line to a circle, but it is usually more or less elliptic.

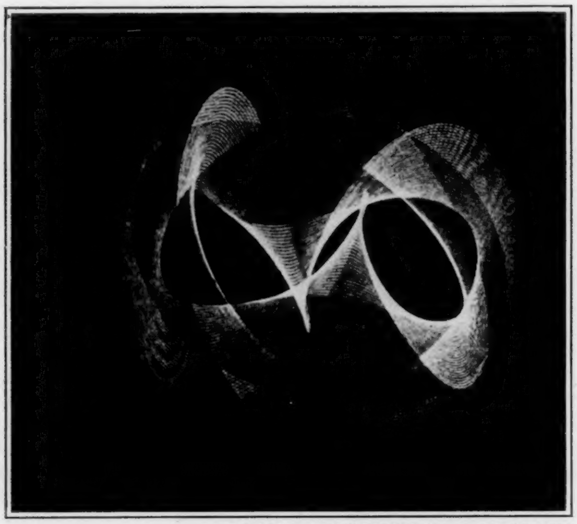
An essential to any apparatus of this class—that is, if it is to possess any scientific value—is that it should be capable of tracing exactly the curves which are compounded, and also that it should record, if necessary, cases in which one of the vibrations is increasing in amplitude while the other decreases. Needless to say, the pendulum cannot achieve either of these *desiderata*. To place the matter on a more satisfactory basis, the writer designed and constructed the apparatus which is illustrated here.

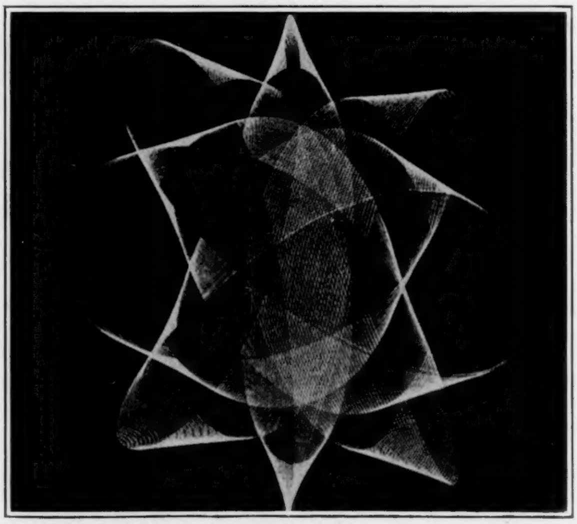
It is difficult to explain in non-technical language exactly what is meant by the composition of the two vibrations. If

*Courtesy of *London Illustrated News*.



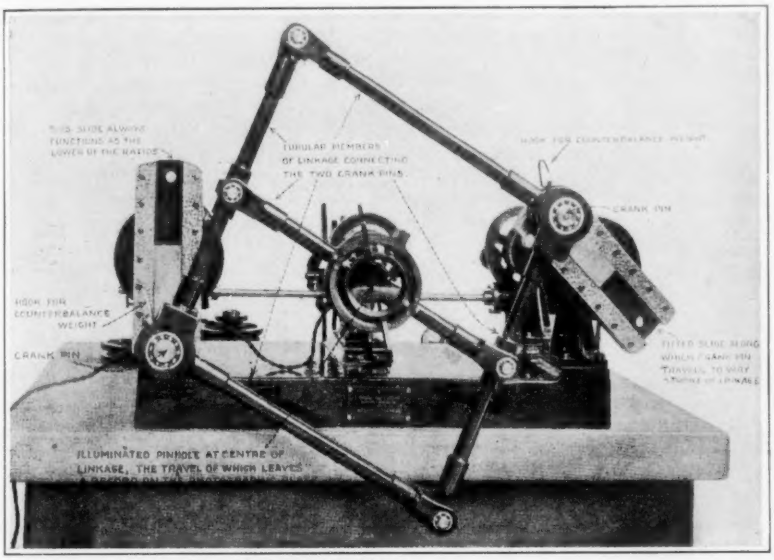






A SET OF INTERESTING CURVES PRODUCED WITH THE PHOTO-RATIOGRAPH
(Note the basic elements of the curves in the upper left-hand engraving)

the reader will turn to the basic elements of the curves shown in the upper left-hand illustration of the curves, he can get an idea if he will imagine an impalpable sort of locomotive progressing around each of the two curves. One of the engines can complete three circuits while the other makes, say, five journeys around the other curve. This gives us our first factor, that of ratio, in the above example 3—5, though naturally it may be any other pair of numbers if necessary. Again, the engines are not limited in the direction in which they may traverse the curves: they may proceed in the same or opposite directions—giving us the second factor, that of rotation, which accordingly is termed either concurrent or opposed.



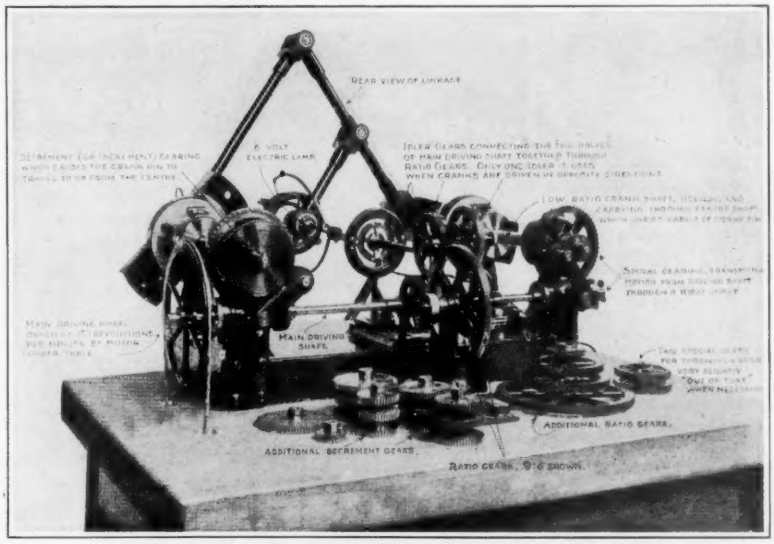
FRONT VIEW OF THE PHOTO-RATIOGRAPH

Several other factors enter into the determination of these curves, but the only other one necessary to notice here is that of decrement (with its converse of increment). Our mythical engines will help us also to understand this. If their supply of steam were unlimited, they could traverse their curves *ad infinitum* at their allotted ratio. However, their supply of steam immediately commences to fail them, and the only way they can keep the ratio constant is to run around a similar but shorter path.

One must not, however, push the somewhat weak analogy of the two engines too far. To get at the real state of affairs, we have to replace them by the force which they represent, a force which is persistent and periodic. It is evident that in such a case the two forces will at times assist each other, and, conversely, will also periodically annul each other, with the result that, instead of our two simple basic elements, we get a more or less elaborate design which represents the compounded path of the two vibrations.

Turning now to the instrument shown in two of the accompanying illustrations, it will be noticed that, instead of depending on the action of pendulums, a mechanical linkage is used to compound the two vibrations. This linkage is of such a nature that the central point, which is represented by a very small brightly illuminated pin-hole, always exactly bisects the distance separating the two crank-pins, whatever their position may be around the circle. The linkage, in short, is a kind of inverted pantagraph. The result of this arrangement is that, assuming one of the cranks is still, on turning the other the pinhole at the center describes a circle half the diameter of that described by the moving crank. By this arrangement it is possible to compound any two circular vibrations.

Compositions of circular vibrations, however, are not the most interesting. By attaching a lamp provided with a suitable pin-hole to various points of the linkage other than the center, an immense and never-failing source of irregular closed curves immediately becomes available. The illustrations reproduced, it will be noticed, belong to this class. In each case the natural vibrations are shown and it seems impossible that when they are caused to interfere with each other the result should be so elaborate. A question is frequently asked of the writer: "Is it possible to reproduce one of these figures?" It is quite easy, and has been done many times, provided that the factors are known, or the basic curves available. It will be noticed that photography has been adopted as a recording medium. This has been done for several reasons. The usual glass pen is a nuisance on several grounds; it is difficult to keep it in order, it introduces friction at the worst possible point, and in these days, when good paper is very difficult to obtain, it is more than inclined to give a bad record. These are absent from the photographic method, which has the additional advantage that the record is an index of the velocity at which the pin-hole is travelling at any given part of the curve; on the print, naturally, the lightest portions are those where it is travelling at its slowest.



THE PHOTO-RATIOGRAPH AS VIEWED FROM THE REAR

In order to make a record, all that has to be done is to start the machine, and let the movement of the pin-hole record itself on a photographic plate, an ordinary camera being used in a darkened room.

The photo-ratiograph as here described is not as yet completely finished. So far it can only deal with strictly circular and irregular basic curves. When complete, its field of usefulness will be greatly extended, for it will be able to deal with eliptic curves and the allied fascinating problems of phase and precession in all their bearings.

Electric Phenomena in Extreme Vacuo*[1]

Can an Electric Current Exist in a Space Absolutely Devoid of Matter

By Dr. H. E. Lilienfeld

ONE of the main principles in physical science is that there are *two kinds of electricity, namely, positive and negative.* Each of these two kinds of electricity may exist quite independently of the other; equal quantities of opposite kinds mutually neutralize each other.

But this original conception of two kinds of electricity has been continually more and more modified of recent years and confined to the special condition that the *negative* electricity is divided into separate particles of like magnitude (quantitatively) and attached to a carrier of their own sort, i.e., the electron whose mass is about 1/2000 part of that of an atom of hydrogen. Positive electricity, on the contrary, is never found except attached to an atom or molecule and does not exist, therefore, except in the form of "*positive ions*".[2]

When we think, therefore, of a portion of space absolutely free from matter—i.e., of an *absolute vacuum*—and question searchingly whether an electric current can exist in such a vacuum and if so, how,—then the answer will be in accordance with the concepts just indicated, that it is probably quite possible to have an "electric discharge" without any participation on the part of matter. It will be characterized, however, by the fact, that *positive carriers of electricity will not appear*—the entire transport of the current in this imaginary experiment (supposed to be carried out in an absolute vacuum) being attended to rather by the negative carriers—the electrons. The electrons will make their appearance at the negative electrode (cathode) K (Fig. 1) in the absolute vacuum and will leave the vacuum once more at the positive electrode (anode) A passing into the circuit.

This simple imaginary experiment suggests some very illuminating reflections. The electrons which leave the cathode move toward the anode with *finite* velocity. Consequently there elapses a finite period of time between the instant at which the electrons leave the cathode and the instant at which they reach the anode. During this period of time the electrons remain in the space which separates the two electrodes. As a result a negative discharge of this space—in colloquial language a "negative space charge"—is occasioned. In accordance with the principle that forms of electricity bearing the same sign repel each other, this existence of the negative space charge exerts a repellent effect upon the electrons which should pass into the space from the cathode and thus makes the passage of the current more difficult. This is shown by the fact that the source of the current E (Fig. 1)—i.e., a storage battery or a dynamo—which makes the discharge manifest must furnish a higher tension the stronger the current of electrons is, and, consequently, the higher the strength of the discharge current in the absolute vacuum is required to be.

As has been often pointed out the above considerations are valid only in the case that there is an *absolute vacuum* inside the glass vessel G which surrounds the electrode—in other words, that there is not a single molecule present in this space. We will now discuss the question as to what change the phenomena would undergo if a very slight trace of gas were allowed to enter the vacuum—possibly through the valve V —while a given strength of the discharge current was maintained. We must keep in mind that the presence of the very first molecule of gas to enter involved the possibility of the appearance of positive ions. That is, when electrons are moving with sufficient velocity and in great numbers in a space containing even a single molecule it becomes highly probable that the said molecule will come in contact with the electrons. When such a clash occurs new electrons are split off from the molecules—physicists term this a formation of positive ions by means of "shock ionization." The presence of

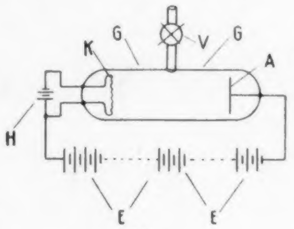


FIG. 1

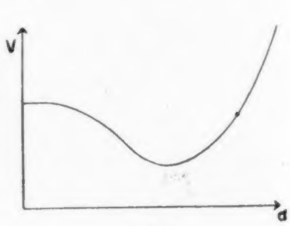


FIG. 2

such positive charges obviously has the effect of neutralizing a portion of the negative space charge. In other words, the space charge is decreased by the appearance of the first trace of gas. Through this, however, the passage of the electrons from the cathode into the vacuum is facilitated, so that the tension required for the introduction of a discharged current of the same strength is less when there is a trace of gas in the enclosed space than that in the absolute vacuum. In fact, the current increases faster in such a case with the augmenting tension than it does in the absolute vacuum.

Let us now continue our imaginary experiment a step further by letting the valve V remain slightly open so that the density of the gas inside of the container G increases very rapidly. If we consider what now will take place from the point of view of the space charge, we can but predict that the space charge will constantly decrease and that hand in hand therewith the tension required for the maintenance of a given strength of current will become constantly less.

However, the point of view of the space charge is entirely too one-sided, by reason of the fact that the passage of the current is influenced in yet another manner by the gas which continues to flow into the vessel with a constantly increasing density. The appearance of a considerable density of the gas naturally occasions a disturbance of the regular current transporting motion of the electron. For the denser the gas the smaller the chance there is that an electron can travel from the cathode K to the anode A in a straight line without coming into contact during its passage with a molecule and thus being diverted from its prescribed path. To this degree, therefore, the increase in the density of the gas increases the difficulty of the transport of the electricity.

This difficulty becomes so serious after a certain degree of density of the gas is attained that as this density increases the *facilitation of the discharge* dependent upon the decrease of the space charge is counterbalanced or even reversed.

The alteration of the tension required for the maintenance

*Translated for the *Scientific American Monthly* from *Die Umschau* (Frankfurt).

[1] Here follows a brief list of the articles pertaining to this subject already published by Dr. H. E. Lilienfeld:

"The Conduction of Electricity in Extreme Vacuo," *Annalen der Physik*, 4th Series, Volume 32, pp. 763-738, 1910; *Annl. d. Phys.* 4th Series, Volume 43, Pages 24-46, 1914; and "Concerning the Discharge of High Vacua," *Annl. d. Phys.* No. 2, Feb., 1920.

Compare also the article "High Vacuum X-Ray Tubes, *Jahrbuch der Radioaktivität und Elektonik,* Vol. XVI, No. 2, pp. 105-189, 1919. The remaining literature concerning this subject will also be found collated in these articles.

[2] So-called "negative ions" also exist. It is generally supposed that a negative ion is formed from a neutral atom or molecule by the taking up of an electron, whereas the positive ion is formed by the splitting off of an electron. According to this theory, therefore, *the magnitude of the electric charge* which is the very foundation of the formation of positive and negative carriers of electricity; in other words, the so-called "elementary charge" would be *always the same.* In a later footnote we shall refer briefly to the researches by Ehrenheft which contradict this idea.

of a given current which is consequent upon an increase in the gas-density may, therefore be expressed as follows (as indicated in the diagram shown in Fig. 2): *The tension V conditioned by the gas-density d=o of the negative space charge is diminished by the first traces of gas, reaches a minimum, and then begins to increase once more as the density of the gas increases further.*[3]

It is of the greatest interest to solve the problem as to what becomes of the energy which is given off from the accumulator battery E to our discharge space. In accordance with the law of the conservation of energy this work done by the accumulator battery E cannot be lost—where then, and in what form will it next appear? The answer is readily found if we again assume to begin with that there is an absolute vacuum. The electrons yielded by the cathode will be accelerated in the field between the electrodes and will absorb the energy in the form of *kinetic energy*. We can represent it to our minds by saying that the negatively charged electrons are attracted by the positively charged anode just as a stone dropped from the top of a tower is attracted by the earth. Just as the stone strikes the earth at its utmost velocity and thereby has its energy transformed into heat, so in the case before us the electron strikes the anode and heats it. Thus we may formulate the law:

The total[4] *energy of the process of discharge will be—given an absolute vacuum—given off at the anode in the form of heat.*

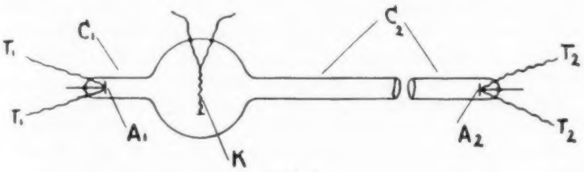


FIG. 3

If, however, we suppose gas molecules to be present in the discharge space then this law ceases to be valid. The mutual impacts which take place between electrons and the gas molecules, under these circumstances, cause a portion of the energy of the electrons to be split off on their way before the electrons reach the anode, by reason of the deviation in direction of the particles due to the shock, and this energy is given off at one side of the glass wall G, which as a consequence thereof, becomes heated. In this case we must suppose, likewise, that because of these electrons which come into contact with the glass wall, and remain hanging there, there does not ensue permanent negative charging of the glass wall—which charging, however, would indeed be hindered by further electron impacts and the durable heating consequent thereupon—by reason of the fact that the positive ions which are present are ready immediately to counteract a negative charging of the glass wall.

Let us now consider how far it is possible to realize the imaginary experiment represented in Fig. 1.

To answer this question two points must be taken into consideration; *first*, the production of a cathode K from which numerous electrons are permanently given off, and *second*, the question as to how far the experimental means at our present disposal will enable us to secure the *ideal condition of an absolute vacuum*. All the other portions of the experiment can be readily realized with the physical apparatus in daily use in our laboratory.

As a matter of fact it is quite possible for the physicist to prepare a cathode permanently giving off a large number of electrons. It was noted as far back as the creation of the first incandescent lamp by Edison that an incandescent filament of carbon (and the same thing was later found to be true of an incandescent metal wire) gives off negative electricity. This phenomenon has been explained by Richardson and his disciples by saying that the heating of the metal causes the electrons which the metal always contains, to enter into lively motion and even enables them to break away from the metal, because the increase in their energy of motion imparts to them the capacity for conquering the superficial tension, which at lower temperatures prevents their exit. In accordance with this view we need only develop the cathode K of Fig. 1 as an incandescent metal wire raised to incandescence by an extremely small accumulator battery H in order to realize the requirements of this portion of the series of experiments involved in the general imaginary experiment.

The second of the two questions, namely, *whether it is possible to realize a sufficiently high degree of vacuum*, cannot be answered in the same simple manner. We must go about it as follows: In a cubic centimeter of gas, at a pressure of one atmosphere and at 10° C. there are contained 2.77 x 10^{19} molecules (according to the Loschmidt calculation). This degree of density of the gas *in vacuo* it is quite possible to obtain by the best modern technical methods including the newer pumps, low temperatures, and absorption process[5], and thus we may achieve an estimated number of 10^{10} molecules to the cubic centimeter. Whether this very respectable degree of vacuum is indeed low enough to cause the theoretically deduced results indicated in the imaginary experiment of Fig. 1, to be approximated, can be decided only by means of experiments consisting of the measurement of current tensions. As a matter of fact I am able to state in this connection that *I have, myself, conducted and described experiments whose results fully correspond to the observations represented in the diagram of Fig. 2.*

Most worthy of note, however, appears to be the fact that series of experiments can be instituted in which the space-charge becomes nil and in which the law of the transference of the entire energy of discharge to the anode *ceases to be valid*. An example of such an arrangement is shown in Fig. 3. We have here a tube provided with an incandescent cathode K and the two anodes A_1 and A_2. The anodes are placed in the two cylindrical tubes C_1 and C_2 having the same inner diameter of about 20 mm. *but being very different in length*. In one experiment the length of C_1 was 80 milimeters, whereas that of C_2 was 700 mm. Under these circumstances the tension required for the maintenance of a given discharge current at the more distant anode A_2 is far greater than the tension required for the maintenance of the given current at the nearer anode A_1. It might be expected in accordance with this that given the same strength of current the anode A_2 would be considerably hotter than A_1.

Observation proves, however, that in both cases the quantity of heat given off at the anodes is practically the same within the limits of possible error.

In this case by far the greater portion of the energy of the discharge is given off at the glass wall in such a manner that even the tube C_2 of the extreme length of 700 mm. is evenly heated throughout its entire length and this to a temperature so high as 300 centigrade. Only a comparatively small fragment of the energy of discharge is shared with the anodes. In physical terms this is to be explained by saying that in the discharge system there is an irregular motion whose energy exceeds by far the energy of the regular current transporting movement.

[3]Phenomena represented in the diagram of Fig. 2 were not only observed by me for the first time, but were likewise indicated in the manner shown.

[4] Strictly speaking a small fragment of the electron energy is converted upon the contact with the anode into radiation, i. e. into X rays. This fragment, however, in the case of the tensions here concerned is less than 1/1000 part of the amount of energy and may, therefore, be ignored in the discussion.

[5] For the purpose of the production of extreme tenuity in gases it is indispensable to have at one's disposal a plant for the liquefaction of gases (a system of low temperature apparatus. Such a plant is connected with the Leipzig Physical Institute, and it is possible here to obtain the temperature of freezing hydrogen. A goal worth striving for is the continuance of high vacuum researches by means of liquid helium.

So far as the foregoing facts are concerned the most obvious conception of the matter is that the ionization of the remainder of the gas must be held responsible for the extraordinary deviations from the ideal case deduced with regard to the absolute vacuum—and this view is especially fatal by the fact that in the cylindrical paths of discharge represented in Fig. 3, there is undoubtedly an extraordinary density of rapidly moving electrons with a comparatively less dense content of gas.

This concept of ionization was accordingly stated by me in the first of my works dealing with phenomena in extreme vacuo. But later observation soon showed that this view was far from providing a satisfactory explanation for all the phenomena involved. And this is chiefly true, indeed, because all of the observable magnitudes undergo practically no alteration, even when the density of the gas varies within wide limits, provided that the variations of the gas density take place under sufficiently low degrees of pressure.[6] It seems, therefore, extremely improbable that it is the ionization of the gas residue which occasions the deviations from the theoretical consequences deduced.

If we compare the experimental results described in a portion of this article with the imaginary experiment described in the beginning and represented in Fig. 1, we are justified, therefore, in forming the following conclusions:

There is a class of discharged phenomena in extreme vacuo which have been thoroughly studied by experimental methods and which fails to agree with the consequences deduced from the theory of a negative space charge. In order to represent these phenomena in a comprehensible (mathematical) manner we are forced to assume that besides the negative carriers of the charge (i. e. electrons) *positive charges also are to be found in the most extreme vacua which it is possible to attain.*

For such a representation of *certain aspects of the phenomenon* it is a matter of entire indifference whether we conceive these positive charges as ions formed from the gas residues by means of shock ionization or in any other way—it is sufficient for this *narrower purpose* merely to recognize the production of positive charges of one sort or another. If, however, we desire to obtain a concept of the results of observation in their *fullest extent* which shall be quite unexceptionable, it is apparently not possible to content ourselves with a simple concept of an ionization of the gas residues. *One possible explanation,* which is the one which comes most readily to mind in so far as it makes immediately comprehensible the independence of the phenomena from the density of the gas, is the theory suggested by myself to the effect that positive quantities of electricity (in what is at first not a more nearly definite manner—i. e. continuously distributed, or united with discrete carriers in quanta) are produced in the discharge system when the space density of the negative electron exceeds a definite limit. As a result of this concept, therefore, there would be *positive charges quite independent of the gas residues* which would abolish the negative space charge and likewise affect the other deviation from the theory. Of course, it must be quite obvious to the reader that *this story of such positive charges[7]—considered from the general scientific viewpoint—involves a new basic concept of vast scope, namely, the possibility of creating a condition of dissociation within a portion of space entirely free from matter.*

In this connection I may likewise remark briefly that the phenomena which make their appearance at the anti-cathode of the X-ray tube also indicate the presence of a characteristic positive charge. But since the anti-cathode of an X-ray tube is, as a matter of fact, the anode of a high vacuum discharge, it may be regarded as evident that fundamentally these phenomena also belong to the subject here treated.

MULTIPLE TELEPHONY AND TELEGRAPHY

THE German State has been carrying out a series of experiments on the use of high-frequency currents in wires for the transmission of several simultaneous sets of telegraphic or telephonic signals. These tests related to such matters as methods of connection, modes of transmitting speech, filtering out at receivers, speech amplifiers, determination of electrical characteristics of conductors and so forth.

Since October, 1919, a line between Berlin and Hanover (300 km.) has been in operation for threefold telephonic conversations, and it is possible for any subscribers in either towns to converse together with their normal instruments. A similar installation is in use between Berlin and Frankfurt (600 km.). The high-frequency currents are generated by Telefunken oscillation valves, and may be adjusted to have wave lengths between 200 and 20,000 m. There are no technical reasons why 10 or more conversations should not be carried on over one circuit, but the installation expense of such a system would be very considerable.

Multiple telegraphy is in many ways simpler than multiple telephony, but the development has been slower owing to the fact that it was not so urgently needed. The first practical tests were carried out on a line of 600 km. length between Berlin and Frankfurt a.M. The signals are given by negative current pulses, while the positive current is used for disconnecting. The pulses are not sent directly into the line, but actuate a relay that throws the high-frequency generator on and off the line in step with the signals. At the other end of the line the high-frequency currents are amplified and admitted to the receiver. The installation has been operating on duplex work since last December, and in 8 to 9 working hours handles up to 2,000 telegrams, or 30 per cent of the total service between Berlin and Frankfurt. Recently the system has been used for sixfold telegraphy on a line carrying in addition one ordinary telephone conversation. This corresponds to a speed of 4,000 letters per minute, or in 8 hours 16,000 telegrams of 10 words with an average of 6 letters, assuming that only half the total time is actually used for transmission.

A few weeks ago a 150 km. circuit between Berlin and Magdeburg has been used for transmitting two simultaneous telegrams by high-frequency currents and Hughes' apparatus, in addition to an ordinary telephonic conversation.—K. W. Wagner, *Elektrotechnische Zeitschrift,* Sept. 9, 1920. Abstracted by *The Technical Review.*

[6] The fact of the independence of the phenomena of discharge of the density of the gas in a high vacuum, which I, myself, had the honor first to discover and describe, is of basic importance in matters of technology. It is through this discovery that we have learned how to avoid the extraordinary lack of uniformity of the early discharge tubes, which we now know were not sufficiently rarefied. Since the technique required for the production of such vacua was likewise prescribed by me, the process was readily carried out. Upon these principles have been produced the modern high vacuum X-ray tubes, whose first instruction owes its origin to me. Furthermore, the sending and reinforcing tubes employed in wireless telegraphy and telephony as well as in ordinary telephony and other domains of science disclose new possibilities of development.

[7] Ehrenhaft has been engaged for a number of years in researches in a peculiar field, namely, that of optical observation upon matter in the form of extremely divided dustlike particles in an electric field. Ehrenhaft believes that he is justified in drawing from his observations the conclusion that the elementary charge of the electron is by no means the smallest negative charge to be found in nature. According to his view point the magnitude generally accepted as the elementary charge of the electron is merely a mean value derived from a great multitude of very various values. This view is contradicted, however, by certain special observations which indicate that the elementary charge of the electron is not a mean value but a fixed magnitude.

In order to call attention to the entirely abstract logical possibility of bringing this last circumstance into conformity with Ehrenhaft's explanation of his experiments that while on the one hand the elementary charge of the negative electron is conceived of as a given inalterable magnitude, on the other hand the theory of a taking up of quantities of positive electricity for the production of smaller charge leads to the idea of a negative electron attached to one of the Ehrenhaft's dust particles. And this is likewise true of quantities of electricity such as are observable in the high vacuum phenomena as elucidated in my concepts of the results of my experiments, and also for this purpose continually divided in smaller quanta than the negative electricity present can be conceived of without involving a difficulty.

Determining Stresses by Polarized Light

Using Transparent Models to Obtain Direct Visualization of the Stress Distribution

By George Weed Hall and Arthur L. Kimball, Jr., M.E.E.

THE efficient distribution of material in designing to withstand stresses in the structure is of prime economic importance, especially in some of the modern mechanical developments, such as airplanes, where weight is a restricting factor. With the widely expanded fields of mathematical computation and investigation of physical properties, engineers often encounter insoluble problems in proportioning unavoidably complicated shapes subjected to varying loads in diverse directions. Sometimes even distribution of static loads cannot be calculated accurately.

Mechanical tests of machine parts or models by duplicating as nearly as possible working conditions and the study of partial failures and fractures, particularly in the more frequent case of rapidly varying loads, serve practically in better disposal of material. The correct detection of causes of failure is, however, sometimes difficult. The quantitative determination of stress distribution and direction at all the various points in machine members is at best an intricate matter. To dispose material in parts without waste and within practical factors of safety at all points constitutes good construction. Obviously modern competitive selling dictates specifically economical designing.

The deductive study of stresses through other than metallic bodies is embraced in the subject of photo-elasticity. This may be defined as a scientific method for determining stresses by transmitting polarized light through transparent models of the members to be investigated. The color effects produced in the model enable stresses to be measured which could not be calculated by mathematical methods.

Models made of glass become doubly refractive when subjected to stress; but nitro-cellulose, celluloid or xylonite, has been chosen for these investigations because of evident advantages. While glass is of crystalline structure and has many physical characteristics similar to those of steel, iron and other metals, its fragility and the expense and labor involved in making specimens are objections. The models also have to be made very thick and the forces applied very great—near the breaking point.

Celluloid possesses all the desirable qualities of glass, may be obtained free from initial stress and can be easily shaped without producing residual stress. It has been proved both mathematically and experimentally that stress distribution deduced from these models show gratifying agreement with stress distributions in all materials obeying Hooke's law, according to which stress is proportional to strain.

Extensive investigations of stresses with nitro-cellulose models have been conducted over a period of years by Professor Ernest G. Coker, M. A., D. Sc., F. R. S., M. Inst. M. E., M. Inst. C. E., and Professor of Mechanical and Civil Engineering at University College, London, England. During the past year Mr. Arthur L. Kimball, Jr., M. E. E., Research Laboratory of the General Electric Company, has been in London for the purpose of studying this scientific work under Professor Coker at the college and instituting similar research here. A special set of apparatus designed by Professor Coker and Mr. Kimball was manufactured in London and has been erected in the Research Laboratory at Schenectady where it is being used for solving some outstanding problems. Professor Coker has collaborated here during the summer in this scientific work, giving his advice and coöperation.

THEORY OF LIGHT

A conception of the nature of light inheres in the comprehension of the behavior of polarized light transmitted through stressed transparent models. Subjectively, light is the sense impression formed by the eye. Objectively, the nature of light is the deepest of scientific research.

The first theories of light were the emission theories, principally the one that light is a stream of extremely small corpuscles which luminous bodies emit and which can pass freely through transparent substances and produce the connoted sensation by their impact against the retina. Sir Isaac Newton championed this hypothesis in so masterly a manner in his "Opticks" (1704) that it held sway until the beginning of the nineteenth century. He, however, had to reject some of the original simplicity of his theory to explain the colors of the spectrum, the equality of speed of propagation of all rays, although it readily accounted for rectilinear propagation.

The wave, or undulatory, theory developed secondly from the trend of mathematical investigation, particularly by Thomas Young and Augustin J. Fresnel. It may be regarded as culminating in the elastic solid theory, or a stationary ether. According to the wave theory light consists of a transverse vibratory motion propagated longitudinally through the ether.

The difficulty of forming an accurate conception of the nature and structure of the ether is very great, and the conventional views concerning it are as yet speculative. It may be considered a hypothetical medium pervading all space, even that occupied by fluids and solids. The functions attributed to it, those of the transmission of light vibrations as well as the production of all the phenomena of electric and magnetic fields of force, exhibit properties different from those of any known form of matter.

The third theory of light resulted from mathematical research of James Clerk Maxwell. The deduction from this hypothesis is that light waves are electro-magnetic, of the same nature as those generated by oscillating electric currents. Yet Arthur Schuster declares in his "Theory of Optics" (1904), "So long as the character of the displacements which constitute the waves remains undefined, we cannot pretend to have established a theory of light." This should be interpreted to mean the real nature of light and related phenomena.

It has been proved the ether transmits waves of every wave length with the same velocity of 300,000 km., or 186,000 miles, per second, which is the fundamental constant at the basis of the theory. That the speed of light does not vary with its wave length has been determined from observation of the variable stars. The situation is different in a refracting medium where the velocity is inversely proportional to the refractive index of the medium, which varies with colors. Ole Roemer first noted at Paris (1676) through observation of Jupiter's satellites, made in different relative positions of the Earth and Jupiter in their respective orbits, that light travels with a definite speed. This has been established at 299,778 km. per second in air and 299,853 km. per second in vacuum.

Monochromatic light consists of a succession of simple harmonic vibrations, the color sensation depending on the frequency. Young and Fresnel explained the phenomena of interference on this basis in connection with the principle of superposition, and from the hypothesis deduced the various wave lengths. Newton's old theory was that a prism actually sorted out the colors of the spectrum,—violet, indigo, blue, green, yellow, orange and red. The new theory is that the prism really does manufacture the colors, the sequence of irregular wave trains of white light being analyzed into a series of more regular trains by the prism.

The range of measured or practical wave lengths of electromagnetic waves is enormous, as illustrated in diagram (Fig. 1), extending from the extremely short X-ray vibrations to the mammoth waves radiated from an alternating current distribution line. The wave lengths, it will be observed, range from less than a hundred-millionth cm. to thousands of miles. It should be considered that there is no discontinuity at limits denoted. Though varying so widely in their manifestations, all these waves are of exactly the same nature and differ only in length. Note the amazingly small range of the spectrum visible to the human eye.

REFRACTION, INTERFERENCE AND POLARIZATION

Refraction of light is the deflection of rays in passing obliquely from one medium into another of different density, or in traversing a medium not of uniform density. A ray passing into a denser medium is bent toward the perpendicular to the surface of separation at the point of incidence, and in passing into a medium less dense is bent away from the perpendicular. The angles between the perpendicular and the ray before and after deflection are termed respectively the angle of incidence and the angle of refraction. The ordinary law of refraction is that the sines of these two angles are in constant ratio, called the refractive index, of the velocity of propagation in any two specific mediums, but naturally it differs for different mediums and depends on the nature of the light employed, or its wave length.

In single refraction the rays are not divided. In unequal refraction of composite light transmitted through a triangular prism, dispersion occurs and the spectrum is formed by the colors arranged in series in the order of their respective wave lengths, or refrangibility.

Interference results from the action of two identical vibratory motions that tend to cancel, neutralize or augment each other by a combination of opposite, intermediate or like phases of motion. With monochromatic light this is manifested by dark bands shading into and alternating with light ones, the width of which differs with the color; hence, with white light, where the bands are due to the superposition of various colored bands of unequal width, bands of several colors are produced.

Double refraction is exhibited when streams of light traverse certain crystals, notably a rhomb of Iceland spar, in which the incident ray is split up into two refracted rays vibrating in straight lines at right angles. The waves are said to be polarized, the ordinary in its principal plane and the extraordinary in a plane perpendicular to its principal plane.

A line joining the two apexes formed by the obtuse dihedral angles is called the optic axis of the crystal. Rays passing through the crystal parallel to the optic axis are not doubly refracted, but are in any other position. A plane perpendicular to any refracting face of the crystal and parallel to the optic axis is called a principal plane.

The vibrations are transverse, i. e., perpendicular to the direction of the ray, and all in one plane when light is fully polarized; while common light has transverse vibrations in all planes. Light is said to be plane, circularly or elliptically polarized according to the nature of the path of vibration.

Polarization may likewise be effected by reflection, repeated refractions and diffraction. In rotary polarization, in which the plane of polarization is altered or rotated, the vibrations take two directions, right-handed and left-handed, one gaining on the other in such a way that, on emerging, they join in a plane polarized ray, the plane of polarization having undergone an angular displacement depending on the nature and depth of the polarizing medium used.

Shortly after Newton made his classical investigations of the spectrum (1665), recombining its colors by means of a second inverted prism, Artolinus discovered (1670) double refraction of light transmitted through the Iceland spar rhomb, which he observed in the form of dual images of a single object. Christian Huygens noted an absence of symmetry in the two transmitted beams. The wavelets of the ordinary ray have a spherical wave-front and those of the extraordinary an ellipsoidal wave-front tangent to the spherical at their intersection with the optical axis or a line parallel thereto.

In his "Traité de lumière" (1690) Huygens published an elucidation of reflection and refraction, as well as double refraction, but the last was not called polarization until E. T. Malus observed the phenomenon (1808) produced by reflection; for he attributed it, based on the emission theory, to a kind of polarity of the light corpuscles.

D. F. J. Arago discovered circular polarization in quartz in 1811 and, with Augustin J. Fresnel, made many experimental investigations which culminated in the formation (1816) of the Fresnel-Arago laws of interference of polarized beams. One of the most important of these figures in explaining color effects produced by stressing transparent models.

The rotation of the plane of polarization by quartz was also discovered by Arago in 1811; if white light is used, the colors change as the Nicol rotates, a phenomenon termed by Biot "rotary dispersion." Fresnel regarded rotary polarization as compounded of right and left-handed circular polarizations. Sir David Brewster conducted polarization research over a wide range. In 1816 he made the remarkable discovery that transparent materials while stressed become likewise doubly refractive, the subject of the investigations by Professor Coker and Mr. Kimball.

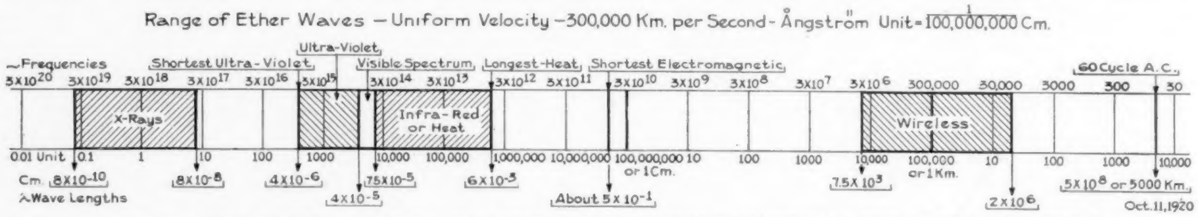


FIG. 1. RANGE OF ETHER WAVES. NOTE HOW SMALL, PROPORTIONATELY, IS THE VISIBLE SPECTRUM

COURSE OF LIGHT THROUGH THE POLARISCOPE

James Nicol devised in 1828 the famous Nicol prism, which facilitated greatly the determination of the plane of vibration of polarized light. The prism consists of a long rhomb (equilateral parallelogram with oblique angles) of Iceland spar, an anisotropic medium, i. e., possessing different properties specifically for the transmission of light along lines of different directions. The acute angles are naturally 71 degrees but are cut down to 68 degrees. The rhomb is cut in two along an axis and the portions are then cemented together with Canada balsam.

The incident ray of light entering one face is divided into the ordinary and extraordinary rays. The ordinary ray is totally reflected out sideways at the interior surface, while the extraordinary ray is transmitted through the crystal and emerges from the opposite face parallel to the incident ray.

The polariscope arranged by Professor Coker and Mr. Kimball operates with a 4-in. diameter beam from a Mazda lamp projector, with condenser, as this lamp gives a more constant beam in focus than an arc projector. The polarizer consists (Fig. 2) of a graduated cylinder, with necessary lenses, in which the first Nicol prism is mounted so that it

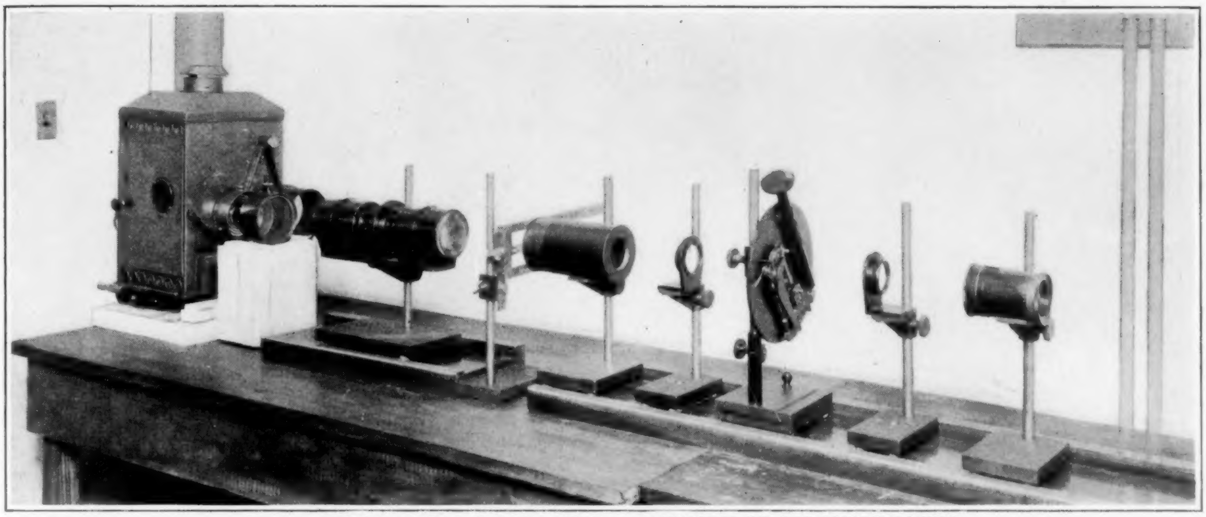


FIG. 2. OPTICAL SET FOR DETERMINING STRESSES BY POLARIZED LIGHT

can be turned about the incident ray as an axis. A second Nicol prism similarly mounted at the proper distance constitutes the analyzer. A filter water screen is placed immediately in front of the polarizer to absorb heat from the incident rays.

The transparent members to be stressed are held between the polarizer and analyzer in a specially screw-operated frame for subjecting tension, or in other apparatus specially devised by Professor Coker and his assistants for applying uniformly such stresses as compression, internal fluid pressure or shear. The light is finally thrown upon a screen for observation of the resultant interference colors.

Ordinarily light from the polarizer is plane polarized. Circularly polarized light is employed, however, to pass through the stressed model; for it can be resolved into any two components at 90 degrees, and the color interference effects are therefore independent of the angular position of the model, depending only on the stress intensity.

Circularly polarized light is obtained from the plane polarized stream by passing it through a quarter-wave plate of mica of such a thickness that it introduces a relative retardation of a quarter of a wave between the component streams within it. The direction of vibration of the most retarded stream is called the axis of the plate. By placing the plate so that this axis is at 45 degrees to the primitive plane of polarization, the light becomes circularly polarized. Conversely, a second quarter-wave plate is located in the analyzer with its axis at 90 degrees to that of the first plate for bringing the circularly polarized light back into a state of plane polarization.

According to one of the Fresnel-Arago laws of interference of polarized light, two streams of light polarized at right angles and coming from a stream of polarized light interfere as common light when brought to the same plane of polarization. But in order to produce interference in this case, it is necessary that one component shall be retarded one-half wave length with respect to the other.

When circularly polarized light vibrating in one 45-degree plane passes through a transparent model, say, of a rectangular plate, and no stress is applied, a black field shows on the screen. If it is subjected, say, to tension stress, which may be represented across any plane section by the vector of an ellipse having the major axis corresponding to the maximum principal stress (p) and the minor axis to the minimum principal stress (q), the effect of the stress is to divide the polarized beam into two component rays vibrating in planes at right angles in the directions respectively of the principal stresses.

Although in the same phase at entry, the beams travel at different velocities through the plate, one being retarded more than the other and with a retardation for simple tension and compression directly proportional to the stress applied and to the thickness of the plate. The function of the analyzer is to select the components of both waves which are parallel to the principal plane of the Nicol and, when brought into this same plane, interference ensues causing the color sensations. The required colors are produced when the final plane is perpendicular to the primitive plane.

Thus the color effects appear entirely from applying stress to the transparent model and in obedience to the Fresnel-Arago interference law stated. As soon as one of these two rays is retarded one-half of a wave length behind the other, the two cancel and the color corresponding to that wave length is cut out. The other colors partially or wholly remain. As the stress is changed a different color is cancelled, and so the remaining color changes as rays of different colors are retarded differently by any given stress. Hence, as the stress in the model is progressively increased, one color after another is progressively cut out, leaving a different color effect on the screen in each case due to the colors remaining. When the stress becomes of a complex nature, the colors vary accordingly from point to point in the image on the screen.

Why stressed transparent materials become doubly refractive is not known. It is a demonstrable self-evident fact, just as moving a conductor through a magnetic field generates an electro-motive force. Neither can we explain electricity. The identity between light waves and electro-magnetic waves, however, is established.

SOLUTION FOR STRESS DETERMINATION

When we apply gradually, say, a tension stress, to a strip of nitro-cellulose, the colors appear in the following order with approximately relative values, the color cycle being repeated in nearly the same manner for twice the stress intensity: black, 0; gray, 3.5; white, 5.5; straw, 8; orange, 10; brick red, 10.5; purple, 11; blue, 13; second order, yellow, 18; red, 21; purple, 22; and so on into subsequent orders.

Where the stress is simple tension or compression from a given system of loading in its own plane, the intensity can be read off immediately from the color scale. If a ring is cut in one side and the specimen loaded like a hook, it is severely stressed at its horizontal section and the distribution across this section consists of tension and compression stress only. From the stresses read off at the various points of the section we may plot curves of distribution.

In most cases the stress distribution is of a complex nature; but it is known that any case of stress in the plane of a plate

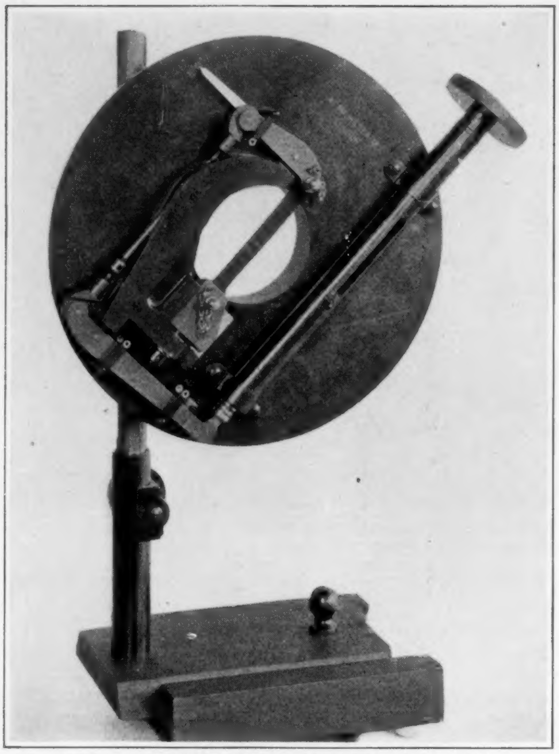


FIG. 3. CALIBRATION FRAME FOR USE WITH OPTICAL SET

FIG 4. EXTENSOMETER FOR DETERMINING CHANGES IN THICKNESS OF SAMPLES

can always be represented by two principal stresses at right angles, the determination of the directions and magnitudes of which at all points solves the stress distribution.

It is first necessary to establish the respective directions of the principal stresses to plot curves. As previously stated, the stressed material causes one of the retarded rays to vibrate in the direction of the major principal stress and the other in the direction of the minor principal stress. The state of stress at any point may be represented by a pair of stresses at right angles through the point.

Between crossed Nicol prisms a stressed plate shows, in general, dark bands marking the positions of all points where the directions of principal stress correspond to the axis of the polarizer and analyzer. These change as the optic axes are rotated and a series of bands is obtained.

If simple tension stresses are uniformly applied perpendicularly, the principal stresses (p) and (q) may then be represented by two systems of lines intersecting at right angles, in which the intensity is indicated by the spacing. Hence, any character of stress distribution in a plane can be represented conventionally by two systems of orthogonal curves, which will be spaced according to the manner the external loads and boundaries of the plate dictate. Across narrow necks they naturally will be crowded together, where the stress intensity increases, and will sweep out again toward paths parallel and perpendicular to similar sides of the plate.

An understanding of the relation of the color effect to the principal stress intensities at any point is next involved in the solution of the problem.

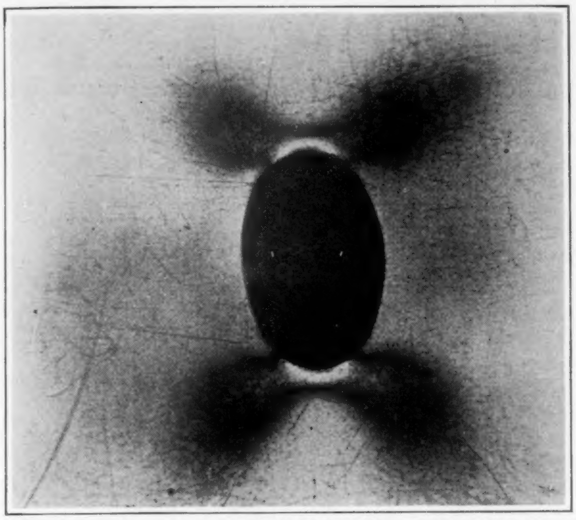
If we superpose two similar tension or compression members, or interpose a double thickness, subjected to the same unform stress intensity and showing exactly the same color effects, the resultant color effect is that produced on a single member under twice the stress, directly proportional to the intensity and to the thickness of the plate. If two equally stressed tension or compression members of the same thickness are crossed, the common area shows a dark field, indicating that they neutralize. An equally stressed tension and compression member placed with the direction of the stresses parallel also give a dark field. Thus, tension or compression stresses in the same direction add their optic effects, and in directions at right angles substract them.

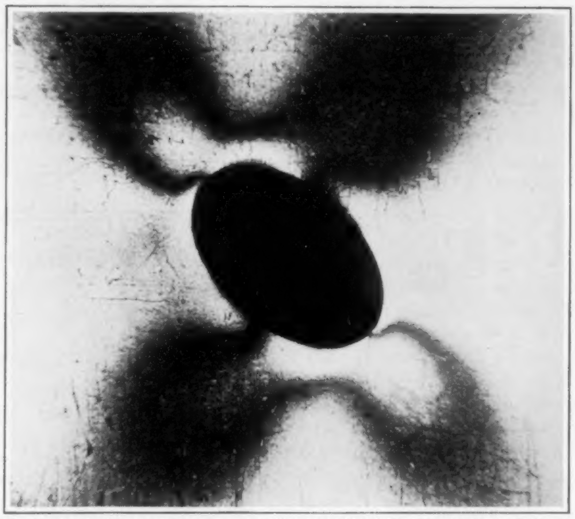
We may therefore always represent the color effect of the stress at any point by the difference (p minus q). Exact quantitative results of the value of the stress difference may then be obtained by matching the color effect at a given point with that on a simple tension or compression member of the same material stressed a known amount, measured by a calibration gauge (Fig. 3). The zero method of establishing optically the stress intensity at any point in the model by balancing to a dark field with the known stressed member is in general more accurate than color occular comparison.

Deductions from the color effect are usually sufficient for stress determination at all edges and boundaries where the greatest intensity exists in most cases. For a complete determination, however, measurements of the change in the thickness of the plate are taken into account by a delicate extensometer (Fig. 4) having a calibration refinement to one-millionth of an inch, observation of which is obtained by mirrored reflection. Stress causes a change in the thickness of the plate proportional to the sum (p plus q) of the principal stresses in its own plane.

If, say, both stresses are tensions, there will be a lateral contraction of (p plus q)/mE, where m is the reciprocal of Poisson's ratio and E the coefficient of elasticity. A fair value of E for xylonite is 300,000 in pound and inch units, and m has a value of about 2.5, so that for each 1,000 lb of stress intensity the corresponding lateral contraction of plates of the usual one-quarter inch thickness is 1/3000 of an inch. Inasmuch as the value of E is much smaller for this transparent material than for a metal, accurate calibration with the extensometer can be done more easily.

In calculating shear stresses it should be considered that the optic effect produced is proportional to the maximum shear (p minus q divided by 2). The directions of maximum shear stress incline exactly at an angle of 45 degrees to the princi-





FIGS. 5 AND 6. THESE ILLUSTRATIONS WERE MADE FROM COLORED PHOTOGRAPHS OF TRANSPARENT MODELS WITH TENSION APPLIED IN A HORIZONTAL DIRECTION

The elliptical holes show a maximum stress intensity at the top and bottom

pal stresses (p) and (q) at all points in a plane stressed member.

It is not difficult to explore the whole of a plate stressed in this manner by determining both the difference and sum of the principal stresses at a sufficient number of points on the lines of stress so found. Curves of the directions of the principal stresses and contour curves of magnitudes may then be plotted; therefore, the problem of stress distribution in a plate stressed by forces in its own plane can be solved completely experimentally.

The permanent strain resulting from stressing materials beyond the elastic limit produces such a change in the structure that the laws of optic behavior of elastic materials cannot be applied *exactly beyond the elastic limit.* It, however, may naturally be inferred that the overstress relations between nitro-cellulose and ductile metals exhibit very similar properties. As the yield point is reached there is a local tendency to stress equalization across the section, which increases as the load is applied. This indicates the value of ductility in preventing excessive strains. Stress strain conditions both in nitro-cellulose and in steel may heal with rest, particularly in hot weather. Recent investigation demonstrates that failures in ductile materials may result from shear. Failures in experiments with transparent models are immediately indicated by the material becoming opaque.

Colors on a stressed model are arranged in bands or figures in conformity throughout with the distribution of stress intensity. If a transparent beam is subjected to a uniform bending moment, observation discloses that the stress varies uniformly from a maximum compression at the under side to nothing, a neutral axis, at the center, and that it then changes sign and increases uniformly to a maximum tension stress at the upper side, exactly the same as in a metal beam similarly loaded. Models of complex shapes exhibit multiform figures (Figs. 5, 6 and 7) of variegated colors changing with varying stresses and thus giving direct visualization of the actual stress distribution.

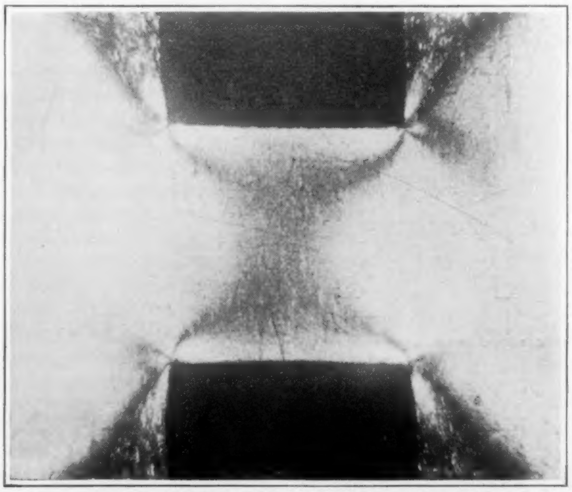


FIG. 7. THIS ILLUSTRATION SHOWS A NOTCHED BEAM WITH TENSION APPLIED IN A HORIZONTAL DIRECTION

The corners of the notches are points of sharp local stress

QUESTIONS OF POLARIZING X-RAYS

This subject is a glance into the future. Scientists dream of the time when we can record observation of stresses due to static loads in metal models, or even in the machines themselves running at full speed, through polarized X-rays.

The Braggs have demonstrated that X-rays can be reflected by means of crystals, and recent experiments by Professor Davis of Columbia University have actually attained over 40 per cent reflection with perfect crystals of Iceland spar. X-rays cannot as yet, however, be refracted, polarized completely or deflected by a magnetic field. Very short and non-periodic electro-magnetic impulses of the ether, they can ionize gases, i. e., render them electric conductors, but they are not bent in passing from one medium into another.

A medium, or method, which will polarize X-rays completely has yet to be discovered. That such a discovery will unfold tremendous utilitarian possibilities is obvious. That it is not impossible has been demonstrated by the researches of Barkla, who has noted what might be termed a partial polarization of the secondary rays amounting to about 15 per cent.

This "polarization" is still more marked if the secondary radiation is excited by means of secondary rays. But it is only the scattered secondary radiation which shows any "polarization"; the characteristic secondary radiation emitted by the body is quite unpolarized.

CONCLUSION

Stress investigation by means of polarized light presents a vast and intensely interesting field for useful exploration. The magnitude of the possibilities for practical application, which are held out by this new method of visual determination of stresses commands deservedly the serious attention of structural and machine manufacturing industries.

Metal Substitutes—I

Use of Various Metals and Alloys in Germany to Replace Those Made Scarce by the War

By General Director Albert Wuerth

With Annotations by C. Powell Karr, Ph. B.

The present article translated from the German periodical Stahl und Eisen, *April 1st, and 29th, 1920, should be of unusual interest to foundrymen and to everyone who manufactures or makes use of alloys in his business. It is a mine of useful information and an astonishing revelation of the inexhaustible patience and marvelous skill of the German metallurgists. The translator, C. Powell Karr, who is a member of the engineering staff of the U. S. Bureau of Standards, has added appreciably to the value of the article by his bracketed notes and criticisms.*

Editor.

THE effects of the scarcity of raw materials caused by the war are sufficiently well known so far as individual cases are concerned. Here we shall describe the ways and means that had to be devised to reduce the disadvantages resulting from the inevitable inferiority of the substitute materials and will show from the results achieved and the experience gained with new raw materials, what promises are held out for future usefulness in times of peace.

The principal manufacturing in question may be grouped in three principal divisions: 1. Driving engine and pump construction; 2. Steam-jet apparatus; and, 3. Heating construction.

1. Engine and Pump Construction

At first engine construction will be dwelt upon and with it the manufacturing of submarine engines, followed by a brief description, because they were built years ago in times of peace.

According to the construction of the submarine, its spacious crank-shaft housing and frame had to be made of a special bronze that possessed surpassing mechanical properties. The resistance to rupture of this bronze ranged from 48 to 56 kg. per square mm. (68,272 to 79,651 pounds per square inch). The elongation had to run from 18 to 30 per cent. In 1917, test bars were cut from the crank-shaft of an average sized submarine, from the marine office in Poland. An official report of the test gave:

Resistance to Rupture Kilograms per square Millimeter		Elongation Per cent	
62.4	Average 61.2 or (87,047 lbs. per square inch,	22.5	average 20.83 per cent
59.0		20.0	
62.1		20.0	

At the beginning of 1915, on account of the scarcity of metals, these crank-shafts or housings and their frames, were made of cast steel which, without special improvements, were immediately available, therefore they led to economy in structural shapes. In the larger submarine engines steel castings were introduced, which was an improvement because they produced greater rigidity in the frame. The only disadvantage was the increased difficulty of working.

All the screws, screw-plugs, etc., which formerly were made of bronze or other copper alloys, now had to be made of iron and be protected from rust by the sherardizing process. Generally the majority of all the parts that were formerly made from copper alloys, now had to be made of sherardized iron, a process which gives scarcely more than a measurable coating of zinc. Another part, like breech-bolts, which had been made of light weight aluminum castings, was now made of thin galvanized iron plates.

The voluminous copper conductors were replaced by steel pipes. In part the piping had to be galvanized both outside and in. The solidly adhering zinc was soon destroyed by sea water and by sea air holding salt in suspension; also, on account of the high electrolytic solution-pressure of the zinc (zinc being electropositive toward iron), the galvanizing coating had to be replaced by lead. The lead coating had the disadvantage that the mechanical deposit did not firmly adhere to the iron, but became detached through outward influences. Hence it was found that the piping must be provided with two metallic coatings which corresponded to the melting point of the deposited metal and these metals, one by one, were applied fiery hot. The galvanizing was followed by the leading process. The application required great dexterity of treatment and a careful maintenance of the temperature range. It was partially established that zinc and lead are soluble in each other.

The main bearing bushings and caps were made from steel or from pressed rolled iron instead of bronze. A further economy in tin was attained in a particular manner. The bronze bushings with the strongest kind of levers (valve-gearing, reverse-gearings) were, until the war, made of bronze containing about 15.5 per cent tin. These bronze bushings and journal boxes were now economized in the amount of tin used by the substitution of a 30 per cent tin-poor alloy, and this was accomplished by resorting to the chill-casting process. (It is singular in this connection that no suggestion occurred to them, nor was there any attempt made to substitute a phosphor tin alloy for tin itself, which would have afforded them the means and power of hardening the copper alloy used, without lowering its tensile strength or other valuable physical properties so greatly in demand, and at the same time save their tin for other necessary purposes. Also it did not occur to them to substitute the well-known nickel-bronzes for the tin bronzes which have been used with success in this country for many of the castings hereinafter mentioned.)

The chill casting process was resorted to in order to secure the hardness reached by a high tin alloy, according to Heyn and Bauer.[1] The mechanical behavior of copper-tin alloys (bronzes) in a great degree depended upon the heat treatment to which they were submitted. An essential effect is produced, namely, by the greater or lesser rapidity of the cooling after casting. A rapidly cooled bronze is, for example, considerably harder than the bronze of the same composition which has been allowed to cool slowly. This fact enables the foundryman to increase the hardness of the alloy, applicable for many industrial purposes, without the necessity of increasing the tin content to accomplish the same purpose. The bronze cast in a chill shows a much closer grain than the sand-cast alloy. A brass alloy above 67 per cent copper is not affected in the same manner.

These bronze bushings with a tin content of about 10 per cent, according to the method of working and the set-up used in the levers by means of a conical punch under heavy hydraulic pressure on their upper surfaces, compressed the metal to a close-grained structure. Neither copper nor brass with more than 67 per cent copper is altered by quenching; they are neither harder nor softer, nor more malleable, as has been erroneously asserted and maintained of copper.

[1]Mitteil.a.d.kgl. M. concerning the influence of heat treatment of bronze for hardness—Berlin, 1910, p. 344.

Metal improvement,[2] such as hardening of hot-rolled brasses, containing 67 per cent copper, as well as of steel and of bronze, should be based upon chemically determined alterations or transformation of structure or upon the appearance of polymorphic varieties which are entirely lacking in copper and higher grades of brass.

Like the copper-tin bronzes, aluminum bronze may be hardened. Experiments were made with aluminum bronze and also with the binary copper-aluminum alloys, but unfortunately their physical properties did not come up to the test requirements for engines. The scarcity of tin, but not of copper, was completely shown here. The already known alloys containing up to 7 per cent aluminum may be hardened. An aluminum bronze with 10 per cent aluminum, for example, after being heated through several degrees up to 800°C. and after quenching, gave a Brinell hardness of 100 to 260.

Close to the substitute metal was a white metal with a tin content of 78 per cent. Experiments with a bearing metal having a composition of 42 per cent tin, 42 per cent lead, 2 per cent copper and 14 per cent antimony, were not completed, but for all that the investigation was further continued. From bronze, only single parts were on hand (their stuffing boxes with high pressure compressors).

The circulating water pump bodies and similar parts of engines were made of cast iron in place of gun-metal and bronze, with considerable reconstruction, such as the reinforcing of their walls. Only pistons and sliding-ring bushings were still made of bronze. The further use of cast-iron as a substitute metal and the difficulties that followed its use, will be mentioned later. An engine or motor made with all of the above described construction and material alteration, appeared plain and dull in comparison with the bright and shining motors made in times of peace. The commutators and new adjustments were proceeded with without great difficulty.

2. STEAM-JET APPARATUS

Greater difficulties were met with in the changing of this apparatus. The use of substitue metals based on many practical experiments for this work was unconditionally necessary. Before the war it appears that only in rare cases were substitute metals used. The points of view which led to the necessary use of copper, gun-metal, bronze, hard lead, etc., are:

1. The lessening of corrosion, in consequence of mechanical, chemical or electrolytic influence and hence:
2. Ready working of the apparatus.
3. A simpler construction.
4. Simpler and cheaper methods of working.

However since then, under the pressure of circumstances, the failure in the use of substitute materials must be taken into account, notwithstanding the fact that substitute metals were earlier introduced into the construction of a vast amount of steam-jet apparatus. In this apparatus there is considered chiefly steam, water, various acids and gases which are under either high pressures or great velocities, or both combined, whether they are the driving or the driven substances.

In the best known steam-jet apparatus, the injector, cast-iron was used in place of gun-metal for the inlet or outlet delivery nozzles. This usage showed that a normal iron as well as a special iron was not sufficiently resistant toward steam and hot water, under the action of pressure and high velocity. The inner contact surface of the nozzle was so much eaten away that the apparatus worked wastefully, and finally some of them failed (became choked up).

Experiments with aluminum alloy nozzles of various sorts were not yet conclusive, it appears however so far as known, that only aluminum bronzes with about 90% copper and 10% aluminum promised any satisfactory results, but of course this effected a saving in tin but not in copper. (In this connection it is singular that no effort was made to substitute Monel metal for bronze in the nozzle construction of injectors. They had nickel in almost unlimited quantities, they had sufficient copper and the iron necessary to make the combination, even if they did not have the ore from which it is smelted in America. By adding a small amount of chrome iron to the combination, an ore of which they had an abundance, they would have been able to make a substitute for the bronze they needed, which would have fulfilled their most severe conditions.)

Moistening devices for air and similar purposes by which the spraying apparatus could be adjusted, were constructed of gun-metal. At first the casing of the old model and adjustments were cast from the so-called zinc-bronze, while the nozzle itself was made of gun-metal. The zinc body, however, was incapable of use, since it fractured under action and turned out to be porous. After alterations the principal casing was made of cast-iron and the inner plug for the water inlet was of zinc, screwed in. Both of the air nozzles were constructed of zinc-bronze. In use, they showed very soon an uneven wearing surface, so that the spray diffusion was unequal, and drops formed. The inequality of surface (corrosion) resulted from the formation of zinc hydroxide. A better arrangement had to be provided to afford in some measure a better spraying service.

The baffle-plate of a pulsometer is of very simple construction; it is generally made of gun-metal. Baffle-plates of zinc-bronze of various compositions cracked after several hours of service or were bent at the lower edges. The later construction of cast-iron turned out better. Copper and brass tubes could not be replaced by zinc tubes as the first experiments clearly proved.

Steam-jet heaters, for certain places and purposes, were made of gun-metal; in the course of time when zinc-bronze was substituted, the operation of the substitute turned out to be a complete failure. An example is referred to in which a marked outward corrosion was perceptible; on the inner surfaces the reaction of the mixture of steam and water developed the decomposition to a greater extent and after several days of continuous service the apparatus became worthless. The fractures in the reinforcing flanges, like the pulsometer and the tubes, showed also that zinc-bronze under high water and steam pressure, had no longer even a claim to soundness. (Manganese bronze castings if made in the right manner, of suitable composition and poured at the proper temperature would have been a good substitute for zinc-bronze for the resistance to corrosion which they would offer for the service they had to perform.)

Very instructive is the evolution of the oil heater, as it was used during the war. The casing and cover of the oil heater were formerly made of gun-metal from the highest grade of marine bronze. As a substitute for the cover, steel was chosen. Difficulties arose with this usage, the cover was then made of cast-iron with its walls reinforced; very soon however it cracked in service. After further construction a steel tube was substituted for the brass tube. The cover was made from ingot-iron disks; the casing on the other hand was made of special steel blocks. Since about 90% of the material was wasted in the working it became too costly a method to use. The riveting of the parts gave rise to many difficulties, so that the case was constructed of plates, which at the bottom and along the longitudinal seams were welded together. The other bottom was riveted to the welded casing. Upon the basis of the experiments in autogenous and oxyhydrogen gas welding methods the cases were for a long time welded together with both bottoms closed by welding. Also the oil supply exhaust whose application to the flame offered many awkwardly accessible places, was welded; so that finally the oil pre-heater from one part to another became concave.

Both of the zinc-bronzes mentioned have been submitted to the most searching and exacting tests, however, in order to obtain the most suitable metals possible which were required for the apparatus that had to be used.

[2] J. Czochralsky-Heat Treatment of Metals, *Giesserei-Zeitung*, 1915, Oct. 1, p. 289.

In combination with the oil pre-heater stands the oil and water gages. Up to the beginning of the war the head of the apparatus was made of gun-metal, particularly of marine bronze. At first substitute steel was employed. In consequence of the intricate core, however, the cast pieces were always useless. Since this method was impracticable, the general form idea was retained; nevertheless, in the alterations the inner channel was taken care of in such a way that it could be bored out, with the head remaining of cast steel, cast solid without a core. This solution also brought no improvement. As a first result it led to a construction that could be built up from ingot iron (mild steel) plates 42 millimeters thick. From this a feasible remodeling was necessary upon the basis of which the head should consist of two parts.

Almost the same development made as in times of peace, in gun-metal, led to the use of exhaust valves for hot oil. When manufactured from cast steel, in the same way for the same purpose, the design became infeasible and the largest part of the castings had to be rejected. At first after the reconstruction by swaging of the driving valve with the corresponding bored work the result was unobjectionable.

It may here be mentioned that all machine construction, chiefly, as also the jet-driven apparatus which in the swage shaped parts found greater use through the experience gained in the war, because of the more accurate measurements of the swaged parts, brought about a great relief from the laborious work of the hand-forged parts. To this came a further reduction in the cost of manufacture, except where quantity production was required. (This admission seems to be almost incredible and is explainable on the supposition that it was impossible for them to build shaping tools, dies and other duplicating machinery fast enough for production on an unlimited scale and also that trained mechanics had been drafted from their forces for the war, so that skilled labor became conspicuous by its scarcity.)

In the forging of the work this was a transition from the shop work to production by machinery, as in the foundries was the transition from bench work to machine molding, by which likewise the quantity production required was not to be considered.

Therefore it can be stated that the extent of the use of substitute metals and substitute construction in jet apparatus as contrasted with general machine construction could be of only a short duration.

3. HEATING CONSTRUCTION

In heating construction metal saving was effected in valves and cocks by the substitution of cast-iron, but especially with a reconstruction of the same. In the larger valves there was a smaller compressed valve-seat and a stem-guide at hand, while the remaining parts were executed with substitute metals; the casings built of cast-iron, the arbors and bolted joints of wrought iron. The same construction proved acceptable for the jet apparatus construction of the necessary normal values. (In this connection it is to be wondered at why the so-called "dur-iron" or high silicon iron was not given a careful try-out for such parts as did not require a high tensile strength, but did call for great density and resistance to the corrosion by acid gases or liquids; perhaps they were secretly tested, but for technical reasons no mention was made of them.)

In the section so far described, which held itself up to the very edge of utility manufacture in times of peace, there now came to be considered the direct manufacture of war-products, which in the department of handicraft, were so far completely unknown. To this work belongs:

1. Construction of bake-ovens.
2. Manufacture of horse-shoes.
3. Manufacture of cold-worked grenades, their machining and methods of filling.
4. Manufacture of gray cast-iron grenades, their machining and operation of filling.
5. Manufacture of projectile fuses, their machining and the labor required.

Of the chemical, physical and metallurgical manipulation the most instructive indeed of all the operations undertaken was the manufacturing of these fuses. In the following text some of the details of the many experiments undertaken, and the difficulties encountered in the application of them to produce practical results will be described. From the necessity of using gun-metal in the manufacture of fuses, the main difficulties were met with in the metal casting and the subsequent shop-work required for their finishing.

(In this connection it is advisable to attempt an explanation of what is referred to in the text concerning "Marine Bronze" and "Gun-metal." According to their own group of metallurgists, scientific men and foundrymen who met in convention in Germany on May 22nd and September 10, 1919, on the question of adopting rules and regulations concerning the nomenclature of Non-ferrous Alloys, they admitted that a great deal of confusion prevailed in the trade as to the actual meaning and correct usage of these two terms. So far as can be learned from their discussions Marine Bronze consisted of an alloy of 85 to 87% copper, 11 to 9% tin and 4 to 6% zinc; that 87% copper, 9% tin and 1% zinc was regarded as a soft bronze, and 85% copper, 11% tin and 4% zinc was regarded as a hard-Marine bronze. Now "Rotguss" or gun-metal had a composition of 86% copper, 10% tin and 4% zinc. In the text mention is also made of zinc-bronze, which is not mentioned in the discussions at the convention; this, however, is the same as the American zinc-bronze, as they frequently adopted foreign names for their alloys, and has the composition of 88% copper, 10% tin and 2% zinc. It will be seen by a close comparison of the compositions that they all belong to the same order of bronzes, with the distinction, that the "Marine Bronzes" were the only ones that steered clear of the transition line between the *alpha* and *beta* formations, and from which solid solutions could be expected and therefore the German metallurgists were correct in their views that it was the best alloy of the group.)

In motley succession the panorama reveals the continuous alteration of the alloys required and these alterations provide the foundations upon which were built the substitution of other metals for the slight changes introduced in the most favorable alloys by which were secured either greater economy in the use of substitute metals or in securing better working conditions.

The development that ensued is comprehended in light of the constant struggle between onerous conditions and stringent requirements. The latter may be considered in three groups:

1. An endeavor to secure the necessary economy in certain metals by reason of their scarcity.
2. Relation to each other on account of the required physical properties, such as tensile strength, hardness, stability in the air and against the deformation of their structure by the process of aging.
3. Requirements of a good working capacity, such as susceptibility to rapid machining and hydraulic soundness to overcome the natural tendency to porousness induced by carelessness in pouring.

The basic metals were aluminum, copper and zinc in varying succession. In their stead were considered experimentally such metals as magnesium, cast-iron, or mild steel. As a result of the reciprocal effect of the basic metals there came into consideration such metals as tin, copper, aluminum, etc., according to the purpose for which they were employed as the source of improving or entrenching their physical properties.

Before describing the course of the development pursued in the adoption of these clever expedients it is necessary to refer to some accessory means of application as follows:

For all the alloys employed in the foundries, graphite cruci-

bles were chiefly used in times of peace. The extraordinary quantity of fuses that had to be poured made it necessary to use enormous quantities of graphite crucibles. Since spathic graphite (about the only kind found in Germany and even that is defiled by the presence of iron oxides or silicates) had become a scarce material early in the war, use was made of iron crucibles alone, of special structure, for all the alloys to be described later aside from the brass alloys and others of a higher melting point. The great quantity originally on hand was done away with shortly. At the beginning the difficulties that arose in consequence of the destruction of the crucibles caused by the combination of the fluid metal charge with the iron walls of the crucible, by reason of the chemical affinity of the zinc in the alloy for the iron of the pot at high temperatures, lay in the formation of an iron-zinc alloy and the mechanical solution of the iron particles, by which the edges of the costly machining and finishing tools were immediately destroyed.

Within the crucible as well as in the firing space were excrescences of a specially refractory encrustation. The stirring tools were not made of iron, but of implements coated with a refractory clay. (They could not get artificial graphite stirring rods such as are used in American foundry practice.) The metal bath had to be stirred with extraordinary precautions and the temperature range controlled by means of a pyrometer. (The persistent control of their foundry products by means of the accurate use of pyrometers, not as a laboratory caprice, but as a faithful friend in need, should teach every American foundryman who ignores this marvelous tool that he is neglecting its assistance to his own costly disadvantage.)

In consequence of the war's consumption, measures had to be taken to save a great many thousands of crucibles. On the other hand many foundries daily cast ten thousand fuses; up to the end of 1917 these were cast exclusively from graphite crucibles, because it had been held impossible to get good results from iron crucibles.

The fuses were cast in chills with a high sprue or waste-head, that without an injurious cross-sectional change passed into the casting and provided a sufficiently large feeding head. The function of the waste-head was to remain hot and fluid longer than the casting, thus, exhausting as much as possible its original form as a feeder, and at its upper part it had to consist of either a thin skin or frail enclosing walls that were encased necessarily by asbestos to reduce the heat radiation as much as possible. There were some cases even where the waste shrink head surrounding the chill had to be especially heated.

Along with the formation of the shrink heads the fuses were provided with chill molds; the pouring temperature of the alloy, the chilling temperature, the kind of casting, the method of cooling the casting, the chemical, physical and metallurgical tests of the same, etc., were the important points to be considered in the production of uniformly good castings. No point was too minute to be despised. Underlying every part of the manufacture, accompanied by the most exacting supervision at every point of departure, so far as it was possible to maintain the composition of the alloy, it assured the obtaining of fuses that were free from objections.

It is still to be observed in the following descriptions of the finishing and splitting tests of each fuse alloy that the simplicity of them, all on account of the same form of fuse for all purposes, is taken as a basis of comparison. In reality the various systems of fuses of the field artillery projectiles have increased. Since their shapes do not deviate essentially from one another the critical examination of the usefulness of the alloys are such that no false conclusions could be drawn.

The first fuse alloy specified was composed of 92% aluminum, 6% tin and 2% copper. This alloy, in times of peace, was used for projectile fuses. The casting of the fuse and its machining offered no difficulties. Tensile strength values, analyses, etc., were not called for. The large amount of tin (6%) was considered the cause of its excellent machining properties, i.e., the making of a good chip in the turning or milling operations.

The lack of aluminum and of tin led to experiments to lessen the amount of both metals in the composition of the fuses, and in an emergency to introduce in their place other metals that could be supplied from the home country. These experiments showed that the reduction of the tin and the aluminum in the composition made it difficult to machine some portions of the fuses; especially in the workshops the best methods of machining were not completely known. The reduction of the tin was the strating point of the limitations that became known. Such an alloy was composed of tin 5.88%, copper 2.21%, lead 0.11%, zinc none, iron 0.5%, silicon none, aluminum the balance. The pouring temperature was from 720C. to 730C. (They would have met with better success had they poured at a temperature just below 700C.) The chilling temperature was from 290 to 310C. Tensile strength was from 8.7 to 9.3 kilograms per square millimeter (12,374 to 13,228 pounds per square inch).

Microstructure, splitting and bursting tests show a fine crystalline structure. The crystal aggregates are both light and dark, tin-rich and copper-rich solid solutions. In the shrinkheads the piping is clearly visible.

The additional experiments as to the scarcity of tin and aluminum were supplemented by experiments with zinc, since zinc was already known and tried out as a substitute for aluminum, but also, because during the war zinc was a metal obtainable in Germany in almost unlimited quantity. Besides, metallographic researches had shown that the structure of most of the aluminum-zinc alloys were homogeneous throughout, hence castings they were suitable for fuse. The solubility of both metals, considering the ensuing degrees of heat, were complete and altered but a little by a reduction of the temperature, so that very dense castings without segregation or abnormal crystal formation was to be expected. From the micrographic structure, cleavage and bursting loads, there is perceptible a crystalline structure of the combination of an *alpha* and *gamma* solid solution. For all the investigated aluminum alloys the crystalline structure is characteristic. Under the microscope (magnification 50 to 60) as also in the copper-poor zinc alloys, the cellular form of structure is recognizable. Through the earlier work of Bénard and Quinke,[3] a cellular formation before the appearance of crystallization is probably to be accepted. The cells—also known as "foam cells"—develop with the freezing of the crystals, however, in such a way that several foam cells previously formed can unite to form one crystal. In the above examples the single crystals appear to have been formed within the cellular walls.

In order to determine the largest amount of zinc permissible there was examined, at first, practically, the known alloy of about 30% zinc and 70% aluminum. It proved to be, however, completely worthless, since, on account of too great a hardness, it was in the normal quantity unworkable. Descending step by step with the amount of zinc used, without the addition of other metals, it was left open, besides, to no objectionable quantity production. On this score there must be considered still an addition of tin. A reduction of the tin to below 4% with simultaneous addition of from 12 to 15% zinc at the cost of the aluminum displaced by it, at that time, no longer allowed for the proportion of a profitable quantity production, or had given rise to a case of production because of the slight experience had in the working and finishing of the fuses. Micrographic structure, cleavage and bursting tests revealed crystal aggregates with the changing compositions.

Addition of lead to these alloys from a metallurgical stand-

[3]Bénard,—Cellular whorls in a film of the liquid—Thesis, Gauthier-Willars, Paris, 1901; Quinke,—The Transition from the Solid to the Liquid State. *Proc. Roy. Soc.*, 78, 1906. p. 60; see also Martens-Heyn: Metallurgical Material for Machine Construction, Berlin, 1912, pp. 204-5.

point was unwarranted, and also led to no tangible results. Further experiments, on this account, were confined to reducing the aluminum by corresponding replacements by zinc, with the intention of keeping the tin down from 4 to 6%. This alloy was found to be completely serviceable. It contained: tin 4 to 6%; copper, highest at 2%; zinc, maximum, at 15%; aluminum the balance.

The alloy was found to be quite acceptable as early as the end of 1914 even with respect to its machining qualities. Thus this fuse alloy preceded the development of the aluminum fuse alloys, since it was not until about two years later that there was any official demand for aluminum alloys with a decreased tin content and the addition of greater amounts of zinc though in somewhat altered form. Finally, after about three years, tin had to be excluded altogether from the fuse alloys. On account of the ever growing scarcity of aluminum a complete change of attitude on this question was soon noted at that time for the production of fuses.

(To be continued)

AIR REQUIRED TO BURN A POUND OF COAL*

By C. C. Phelps

POUNDS of water evaporated per pound of fuel, or per pound of combustible, is the telltale of a boiler plant's efficiency. This ratio, in turn, depends primarily upon another ratio—that of pounds of air supplied to burn each pound of fuel. If the air-fuel ratio is large, the evaporation will be low, and conversely, if the air-fuel ratio is small the evaporation will be high unless other factors interfere. It should always be the aim to burn fuel with the minimum quantity of air that will give practically complete combustion. The indication of such result is, of course, high CO_2, as shown by the table.

WEIGHT OF AIR PER POUND OF CARBON IN THE COMBUSTIBLE AS INDICATED BY CO_2 IN THE FLUE GAS

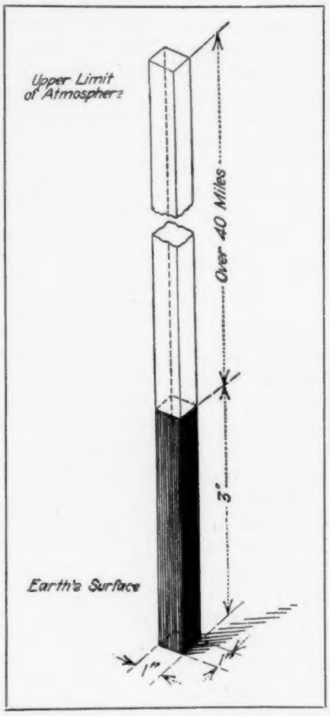
Per Cent CO_2	Pounds of Air	Per Cent CO_2	Pounds of Air
21	11.6	10	24.4
20	12.2	9	26.1
19	12.8	8	30.5
18	13.5	7	34.8
17	14.3	6	40.7
16	15.2	5	48.7
15	16.2	4	61.0
14	17.4	3	81.3
13	18.7	2	121.8
12	20.3	1	244.0
11	22.1		

It is a general mistake to give more thought to the fuel than to the air supply, in spite of the fact that from fifteen to fifty or more times as much air as fuel enters the boiler furnace. Air being invisible, many engineers and firemen do not appreciate how much of it they deal with daily.

A pound of carbon, the preponderant element of fuel, requires 11.6 lb. of air in theory for its complete combustion. Actually, it requires more because there must be 40% excess air to provide for the difficulty of mixing the air and fuel completely while burning. Therefore coal containing 10 per cent ash and burned with 40 per cent excess air would require about 14.6 lb. of air per pound of fuel.

We know that the pressure of the atmosphere on each square inch of the earth's surface at sea level is 14.7 lb. That means that all the air directly above a square inch of the earth's surface weighs 14.7 lb. The earth's atmosphere is estimated to extend up into the sky for a distance of over forty miles from the earth's surface. Such a column of air, then, one inch square and over 40 miles in height, would be just about sufficient to completely burn a pound of coal if it could be brought in contact with the fuel. The pound of coal would occupy a volume of about 36 cu. in. or a column 3 ft. high with a one square inch base. Although the forty-mile (or more) column of air certainly makes the little column of coal look insignificant in comparison, it must be borne in mind that this proportion represents best conditions and in practice two or three times as much air is frequently employed, to the detriment of high efficiency.

A similar mass of air on the ground would, of course, occupy a smaller volume because of the greater and uniform density of the air at the earth's surface. Nevertheless that figure is correspondingly impressive. One pound of air at 62 deg. F. and atmospheric pressure occupies 13.14 cu. ft. Therefore, 14.6 lb. of air, the amount required to burn a pound of coal, would occupy 192 cu. ft. of space. Multiplying this figure by 144 gives 27,648 ft. (or 5¼ miles) which is the length of a column of air 1 in. square, of normal atmospheric density, required to burn one pound of coal (about 36 cu. in.). This air represents 9,216 times the volume of greatest quantity of coal which it can burn, namely, 36 cu. in.



AIR REQUIRED TO BURN A POUND OF COAL WOULD MAKE A COLUMN 1 IN. SQUARE REACHING TO UPPER LIMITS OF THE ATMOSPHERE

*Reprinted from *Power*, Nov. 2, 1920, p. 703.

ELECTRIC HEATING DECLARED IMPRACTICABLE

NO PRESENT possibility of using hydroelectricity for heating purposes is seen by C. A. Magrath, formerly Fuel Controller of the Dominion of Canada. For this conclusion Mr. Magrath gives three reasons. First, although the potential capacity of Canada's water powers is enormous, they are insufficient to heat electrically its present homes, to say nothing of future growth, and at the same time to meet the light and power requirements; second, the tremendous cost of the power plant and of the power transforming and transmitting equipment—all of which would of necessity be in use at the same time in cold weather and none of which would be needed for heating in warm weather—puts electric heating beyond practical consideration; third, the proposal to use electrical energy for heating is based upon unsound scientific principles. Electricity should not be wasted; but in the ordinary electric heater the heating element is in the form of resistance, and all the energy is thus of a low type.

To heat electrically 20,000 houses each needing 25 hp. at the same time would entail a power plant and transmission installation of 500,000 hp., Mr. Magrath estimates. This is twenty-five per cent more power than the total capacity of the three large power companies located at Niagara Falls, Ontario.

If there were so much water power available that there was no economical use for it, now or prospectively, there might be some excuse for advocating electric heat, the former Fuel Controller concludes; but when ten times as much coal can be saved at every point where electric motors replace steam-driven machines as could be saved by the same amount of energy used for electric heating conservation efforts should be centered on the electric power question—not on the visionary project of electric heating.—Reprinted from the *Electrical World*.

Research and Boards

Need of Establishing Laboratories to Study the Problems of the Lumber Industry

By Ovid M. Butler

Assistant Director of the Forest Products Laboratory at Madison, Wis.

THREE hundred years ago the first sawmill in America was built in Maine. It antedated by forty years the first sawmill in England, which was promptly demolished by a mob as a device of the devil. Although the early New England mill fared better, it is safe to assume in the absence of complete historical records that its advent was greeted with suspicion, ridicule, and skepticism. Nevertheless, its success as an improvement over existing hand methods is attested by the fact that, in the years immediately following, a dozen or more similar mills appeared throughout the colonies.

For 200 years this type of mill, with slight improvements, prevailed. It was operated by water power and consisted merely of an upright sash-saw with a capacity of from one to two thousand feet daily. The belief that it represented the perfection of lumber-manufacturing machinery undoubtedly prevailed until early in the 19th century, when the application of steam to sawmills in New England, and the successful introduction of the circular saw (about 1860) multiplied by four and five the output of the water-power sash-saw and opened an era of invention in logging, milling, and wood-

ONE COMMON WAY OF SKIDDING LOGS IN THE EARLY DAYS

working machinery. Within a few decades these inventions lifted lumber manufacture from 250 years of crudity into one of the most remarkable, useful, and diversified industries of our economic life.

Thus, a steadily increasing knowledge of steam-power and machinery has been the great productive force in lumber and wood manufacture and in wood utilization, and out of hit-or-miss studies, experiments, failures, successes, a mass of diversified machinery has been evolved which, with bewildering rapidity, converts the standing forest into a multitude of finished wooden articles or their component parts. Overriding skepticism, ridicule, and often hostile opposition, this mechanical science has carried forward irresistibly the whole lumbering and wood-working industry and made it the second greatest of the nation. It has made wood available in a greater variety of useful articles than any other material with which man comes in contact, and by so doing it has created greater wood demand and wood supply.

Our forefathers used the crude water-power sash-saw and laughed at efforts to improve it, because their minds failed to grasp and apply the theories of steam power and circular saws. Once those theories were given practical consideration instead of skeptical ridicule, however, an invisible power transformed within a single generation our whole wood-using world. Theoretical nonsense, new-fangled or long-haired ideas, pure or applied science, scientific or industrial research—all are familiar terms that may mean much or nothing. The outstanding fact is that from the beginning of time the creative source of this transforming power has been the mind of man, stimulated by inherent desires or worldly rewards to do new things and to find better ways of doing old things. Despite prejudices which may prevail with respect to the word, let us call this functioning of the mind "Research"—organized or unorganized, systematic or unsystematic, scientific or unscientific—and think of it merely as the acquisition of knowledge and its application to the advancement of industry and society.

It is through research that "fools" and "wise men" have evolved the diversified forest products of today—lumber, pulp and paper, naval stores, tannin, ethyl alcohol, fiber silk, preservatives, etc.—products which touch the daily life of every man, woman, and child of our country. It is said that a hundred years ago a chemist boiled up some cellulose in the form of an old shirt, with sulphuric acid and amazed the world with the discovery that the cellulose was converted into sugar. In any event, laboratory research has developed the commercial processes whereby thousands of gallons of 95 per cent grain alcohol are now made from yellow pine sawdust. From one cord of waste wood approximately 20 gallons of the highest-grade alcohol found on the market today is reclaimed.

For centuries man has searched for a practical method of extracting the fibers of the wood. It was not until the middle of the 19th century, however, that Burgess, after several years of unsuccessful experiment, discovered that by boiling wood in caustic alkali at high temperatures a good pulp could be produced. After the close of the Civil War, Tilghman, experimenting with a solution of sulphurous acid to dissolve the intercellular matter of wood, made the further discovery that it yielded a pulp suitable for paper. These individual and fundamental researches revolutionized the whole industry of paper-making within a few years and laid the foundation of an industry whose annual output in America today is many millions of dollars and whose product has made us the greatest readers and the most enlightened nation in the world. Within a period of twenty years, this youthful industry reduced the price of newsprint paper 75 per cent to a point which has enabled our newspapers to reach the staggering daily circulation of about 27,000,000 copies, or one copy every day for every family in the land.

In the same way every forest industry can be traced back to some form of research, rough and uncoördinated though its origin and development may have been. In dollars and cents alone these allied forest industries are steadily enhancing the commercial and economic value of forests. Here is an estimate of how a few of them stand today:

Industry	Annual Value of Products
Pulp—Chemical and ground wood	$300,000,000
Distillation, hardwood and softwood	100,000,000
Naval Stores	60,000,000
Veneer	100,000,000
Miscellaneous—Chemical, oils, etc.	10.000,000
Tannin	40,000,000
Wood preservation	50,000,000
Containers (wood-fiber and veneer only)	200,000,000

STEAM SKIDDER WHICH ASSEMBLES LOGS FROM HALF-MILE CIRCLE

THE OVERHEAD SKIDDER SIMPLIFIES THE HAULING IN OF LOGS IN ROUGH COUNTRY

RAILWAY INCLINES ARE QUICK MEANS OF TRANSPORTING LOGS DOWN A MOUNTAINSIDE

Almost a billion dollars added to our national wealth annually! These figures, fragmentary though they are, stand as a credit account in favor of research—unorganized, haphazard, individualistic research in an industrial field in which it has never been given general encouragement or recognition.

The lumber industry for years has been cutting its cake greedily and eating the heart of it. The rest has gone to waste, plate and all, where land fit only for growing forests has been stripped and left unproductive. No one ventures to assert with precision what this waste aggregates annually, for estimates run into staggering figures. The woods and mill waste alone has been placed at about 62,000,000 cords annually. This gigantic waste has been justified by the industry on the ground that it is unmarketable. The industry asserts that it cannot practice forestry because stumpage values are too low and too uncertain to assure profitable returns. Stumpage values are, of course, determined by what can be obtained from standing timber, whether boards only, or boards plus pulp, tannic acid, ethyl alcohol and other by-products. There is reason to believe that, in the waste incidental to present lumbering practice, there are values and profits greater than those realized on the material marketed; but these values can be salvaged only through systematic and well directed research.

An example will serve best to illustrate how utilization growing out of forest research, fragmentary though it is today, enhances the values of stumpage and of forest land. On a 30,000-acre tract in Pennsylvania, averaging 18,000 feet of hemlock and 4,000 feet of scattered hardwoods, the following utilization has been developed: Hemlock logs are manufactured into lumber and the hardwood logs into barrel-heading and staves, except the small amount of cherry which goes into material for cabinet work. The hemlock logs are barked before going into the sawmill and the bark is sold for tannic acid. Dead hemlock and hemlock tops go into pulpwood. The best slabwood and edgings are sawed into lath, and the rest is made into kindling wood. The waste from the hardwoods, including tops, large limbs and defective logs which in most operations are left in the woods, is utilized by a destructive distillation plant in the manufacture of wood alcohol and acetate of lime. By this utilization, the stumpage owners have increased the value of their stumpage by 35 per cent. Such complete utilization is profitable only under specially favorable market conditions, but the absence of such conditions in no way precludes opportunities for research to develop new processes or new products which would place forest waste elsewhere on a marketable plane.

As one reviews the benefits to such industries as cotton, steel, concrete, meat-packing and agriculture, it is not difficult to understand why within recent years research is being more and more recognized by the progressive industries as a business asset, an invaluable resource lending itself to profitable organization and capitalization, and why it has been given a definite and recognized industrial status.

But what of the lumber manufacturer, the man whose business it is to make boards? Unfortunately, there are some lumbermen who still think of lumber only in terms of trees and boards and of research only in terms of whiskers and microscopes. They fail to appreciate the fact that, in worshipping the band-saw, they are paying tribute to a symbol of research. They are apparently unmindful of the fact that the lumber industry, despite its wonderful mechanical development, awoke suddenly a few years ago to a new and insidious competition—a competition wholly from without and sharpened with the deadly accuracy of intensive, well-directed industrial research—which challenged the industry's knowledge of its own product and speedily found out and played upon its weaker side. Today substitutes have replaced wood to the extent of eight or ten billion feet annually and are increasing that figure at the rate of a half-billion feet or more each year.

Considering the ages through which wood has been used, it is a strange anachronism to find that the weaker side of the industry is its lack of knowledge respecting its own forest products, the mechanical, physical, and chemical properties of the various species of wood. Figuratively, the industry, by the force of spontaneous mechanical research, has pushed its manufacturing artillery to the front-line trench of progress; but it has woefully neglected its ammunition. The production of more boards will no more solve the future problems of the lumber industry than the production of "duds" will win future wars. While it may change ledger figures for the year it won't sell lumber during the next period of depression when selling charts show orders and shipment consistently below production.

The great board capacity of the lumber industry is indeed a liability of variable dimensions; it is a cost which must be written off. As production decreases, the board price to the public must increase. Low production with its high-unit prices stimulates inroads of other materials as substitutes for wood. Where the value, adaptability, and serviceability of these sub-

stitutes have been determined by intensive, organized research (as they are coming more and more to be) it will be increasingly difficult for the plain board to "come back" when investments in place force production in excess of demand.

The making of plain boards is a business proposition and the manufacturer who sells them at less than the cost of production is obviously performing a critical operation on his business and is helping to undermine his industry; though probably to no greater extent in the long run than the manufacturer who puts boards on the market at a cost of ten, fifteen, or twenty per cent greater than is necessary, and is thereby merely inviting competition by creating markets for a cheaper substitute, antagonizing the public against the industry in general, and stimulating research on the part of the substitute competitor, to an extent which will never be known until a "research inventory" is as much a part of the industry as the "stock inventory." No assertion is made that the cost of making boards is ten or twenty per cent higher than it should be; but the point emphasized is that, in the absence of research, the industry does not and never can know the possibilities of reducing costs.

Some of the more progressive industries have adopted the slogan, "Business Follows Service," which is tantamount to saying that service precedes business. In other words, service must first be developed upon the sound basis of determining within lines of close accuracy the adaptability and serviceability of the product. Research is the grist-mill of such service, because it grinds in terms of definite and proven rather than preconceived or rule-of-thumb standards. The business or industry whose methods and products are worked out, advertised, and sold upon a well-organized and coördinated policy of research is the hardest possible competitor especially for a business or an industry not supported by research practice. In short, before wood markets can be permanently stabilized and held, the industry must be assured that it is producing, advertising, and marketing its product as scientifically as its substitute competitors.

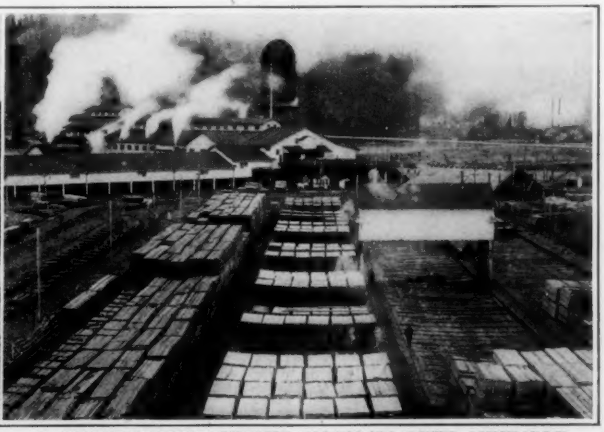
Of the five leading manufacturing industries of the United States, the lumber industry is the only one that does not maintain a research laboratory for the scientific study of its products and of its manufacturing and marketing methods. A number of the stronger associations, appreciating the need of work along this line, have employed a limited number of specialists; but the only commercial research laboratories receiving the financial support of the lumberman are those in other industries. The graves of empty food cans at the rear of every cook shanty bear mute witness to the truth of this statement, for in providing his camps with canned food the lumberman is contributing his tithe to the research laboratories of the National Canners Association. Similarly, when he installs a special piece of electrical machinery in his mill or in his home, he is supporting in dollars and cents a research laboratory maintained by the electrical company. When he elects a State assemblyman who goes to his State Capitol and votes a substantial appropriation for the State agricultural experiment stations, he is supporting research and usually getting good returns on his money. In his own business, however, research as an investment seems to be persona non grata.

There are few industrial fields in which the opportunities for profitable dollars-and-cents research appear greater than in the lumber and wood-using industries. Aside from the work done by the Government and a few universities, which is woefully limited because of inadequate appropriations, the lumber industry stands conspicuous by the absence of a research program. From the cruising of the timber, prior to purchase or cutting, to the writing of the advertisement which aids in marketing the lumber, there are possibilities for improvements, which under the analysis of research should yield profit, stability, and strength to the individual lumberman and to the industry. If, for example, the shingle manufacturer could write into his advertisement a guarantee that his shingles had, by a certain treatment, been rendered fireproof, it would help his sales and the whole shingle industry. If the writer asserted to the average lumberman that by simple treatment his sawdust could be converted into a palatable and nutritious cattle food, he would undoubtedly be set down as a theorist and a dreamer, yet research has, within the past few months practically establish that fact.

Individual lumbermen probably recall wakeful nights during which they have endeavored to formulate plans for utilizing their waste; but where markets for raw waste have not been available, their mental efforts have in most cases been in vain, and not infrequently they have squandered good money in trying to carry out their ideas. It is certain that failure to make any great progress in developing waste untilization by realizing on intrinsic value in the wood itself is due primarily to the ineffectiveness of haphazard, individual efforts by men trained in lumber manufacture but untrained in chemistry, wood technology, and the methods of the research engineer and forester. Without this technical personnel, the industry will ever stand unprepared and unable to assume its rightful place in the casting and progressive development of a wise and fair National Forest Policy of which research in forest management and forest utilization is the foundation.

An evening spent in reviewing the progress of industrial research in this country should convince the most skeptical that there is something worth while in it. Take, for example, the Portland cement industry—foremost competitor of the lumberman. To scientific studies and tests the general manager of the Portland Cement Association attributes the reinforced concrete building of today and other innumerable articles of concrete not on the market ten or fifteen years ago. The rate of progress of this industry in productive wealth reads like a great gold discovery. During a period of twenty-

AN OLD SAWMILL SUGGESTIVE OF EARLY METHODS



A MODERN MILL CUTTING 100,000,000 FEET ANNUALLY

five years, the value of the industry's annual production advanced from $439,000 in 1890 to $74,000,000 in 1915; in the ten years preceding 1915 the value of the industry's raw product increased almost 300 per cent. Yet men in the industry view their progress as merely at the threshold of concrete's possibilities.

Perhaps the one company in which research has been made a part of its business to a larger extent than in any other is the E. I. DuPont de Nemours Company. This company developed its first research laboratory in 1908, at which time it was spending $220,000 annually. Today the company has a number of large laboratories, and in 1918 was spending $2,000,000 annually in research work. The chemical director of this company has stated that from 1912 to 1915 the company spent $1,200,000 on research and effected a saving of $14,000,000—a handsome profit, however one may look at it. These figures speak significantly for research as a profit-bearing investment.

The first coöperative research within an industry undertaken in this country was by the National Canners Association in 1913, when the research laboratories of that association were organized. The canning industry, like the lumber industry, is composed of relatively small individual plants; and problems are largely common and general, so that individual companies cannot afford to undertake research on an extensive scale. Results under a broad program of coöperative industrial research have been so successful, however, that the work has been gradually enlarged and extended from year to year. No event in history has called attention to the value of industrial research so conspicuously as the war just closed. Since the signing of the armistice, many industries which had not heretofore given thought to the potentialities of organized research from the standpoint of common business needs and protection are taking steps to provide money and facilities for intensive coöperative work along this line.

Few lumbermen can afford, individually, to undertake extensive research, because of the inherent character of the industry. Most effective and far-reaching benefits will come through united and coördinated programs of regional research, which the industry as a whole will support as a part of a national program of coöperative research. Three broad fields of opportunity are open: (1) The establishment of laboratories directed and operated either exclusively by the industry or in coöperation with the National Research Council; (2) The establishment of research fellowships with recognized research institutions, universities, or National Research Council and Government laboratories; (3) Specific contracts or agreements with commercial or non-commercial research organizations qualified to perform the character of work required.

Lumber associations are today spending from a few cents to as much as $2 per thousand feet for advertising and promotion purposes. Over a period of years, 10 to 15 cents per thousand devoted to research would, it is believed, yield higher and more permanent returns and render far greater service to the industry and the public. Second in national rank, the lumber industry should have a research laboratory or at least a research program worthy of its position and its needs and with adequate financial support.

GIVING PLANTS MEDICINE

By S. Leonard Bastin

The statement that a sickly maidenhair fern has been given a new lease of life by the administration of cod liver oil is not at all surprising. During the last few years it has been shown that plants often derive a great deal of benefit from suitable medicines. Now and again plants suffer from a kind of anaemia which manifests itself in pale green foliage, and lack of color in the flowers. This trouble is largely remedied by the use of iron. Water, which has been made rusty with iron is employed, or even iron filings are worked into the soil round the plant and a speedy change in the health of the plant takes place. The foliage assumes a deep green shade and the flowers develop a strong color. Where the amount of iron is large surprising alterations will sometimes be seen in the colors of the blossoms. Thus, now and again, pink flowered hydrangeas will bear blue blossoms under such treatment.

Alcohol has a stimulating effect on many plants. White-flowered primulas and sweet williams were given small doses of alcohol for several days and, at the end of the period, the plants started producing blooms of a bright pink shade. In some way the alcohol brought into activity the latent color in the petals of the flower. The medical treatment of the plant does not merely consist in giving doses at the roots. A weak solution of sulfate of iron applied to the foliage and even the fruits of a tree will act almost magically. This chemical has the power of stimulating the action of the leaves and fruit in drawing sap from the roots. Thus the foliage and the fruits show a development which is greatly in advance of anything that is grown normally. Plants which are kept for the sake of their foliage, such as palms, benefit greatly if now and again the leaves are wiped over with milk, or pure olive oil. The application has a wonderful restorative effect and the leaves remain in a very healthy state.

A few years ago it was discovered that plants were very much affected by anaesthetics. A lilac bush submitted to the fumes of chloroform for two or three hours behaved afterwards in a very astonishing way. Although it was the middle of winter the bush soon after it had been chloroformed started to develop its leaves and flowers. In some way the deep sleep which the anaesthetic induced appeared to take the place of the winter rest period of the plant. Thus, when the bush woke up, it started to grow with all the vigor of the spring. The use of anaesthetics for the forcing of plants into a premature maturity is likely to prove of great value to the gardener.

GRASS AND COTTON

The *Color Trade Journal* for August discusses a discovery by Japan of a new fiber to mix with cotton which promises to bring about a decided change in cheap fabrics in the Far East. The fiber is a kind of sea grass known as sugamo which, under proper treatment, makes a strong thread and is useful for cheapening the material which is now high in price. At present the annual value of raw cotton imports to Japan is about 300,000,000 yen, and if the proposed mixture proves successful this large import of raw cotton can be reduced.

There is said to be no difficulty about a sufficient supply of the grass, which is found in abundance along the shores of Japan. The botanical name of the plant is *Phyllospadix Scouleri*. It is an evergreen about one-eighth of an inch to three feet in width, sometimes sixteen feet in length, and thick, somewhat resembling our kelp. The use of this weed in cotton spinning has just begun and was first tried in making material for horse blankets where success has led to the consideration of its use in other fields.

The secret of the process of preparing the grass is to know how to remove the outer casing of the weed, and this process has been patented. The procedure is said to be somewhat as follows: The dried plant is first boiled in lye for two hours and then allowed to cool. This weakens the skin, so that it comes off without resistance, when the material is washed in water and boiled again, bringing it just to the boiling point for half an hour in water mixed with rice bran. The fiber remaining after this treatment looks like cotton from which any remaining particles of the sheath are removed by rinsing.

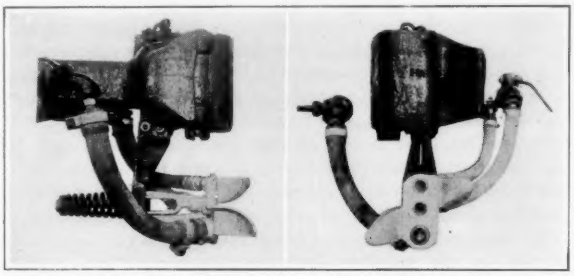
It is claimed that cotton mixed with this fiber produces a stronger thread than when cotton is used alone and that fish nets made from this mixed yarn withstand the wear and the action of the water for three months or more without showing any effects. This is much better than pure cotton thread can do and indicates the possibilities.

The Marvel of Train Control

New System of Automatically Connecting the Air and Steam Hose of Railway Cars

By Robert G. Skerrett

HOW many of us realize just what happens when a powerful locomotive, with a string of cars behind it, gradually gathers headway until it is racing along at the rate of quite a mile a minute? The engine besides pulling a train of heavy Pullman coaches, for instance, is, simultaneously storing up energy in the whole moving mass. That momentum might easily invite disaster if it were not practicable to bring the train to a halt within a span of a thousand feet. Similarly, present-day schedules of passenger service could not be maintained unless the man at the throttle on the locomotive had at his command a medium by which the whirling wheels of his engine and those of the trailing cars could be gripped by brakes and progressively checked. Finally, the management of slower and far more ponderous freight trains would be an exceedingly risky matter when climbing mountain slopes or traveling down steep gradients but for the part played by the automatic brakes fitted to each car.



SIDE AND FRONT VIEWS OF THE AUTOMATIC TRAIN-PIPE CONNECTOR ADAPTED FOR PASSENGER SERVICE

It is doubtful if George Westinghouse visualized more than imperfectly the potential benefits that would flow from his pneumatic brake, brought out fifty-three years ago. True, he realized that it was quite as important to be able to halt a train at will as it was to give it all of the headway possible with the locomotives of that period; but he could not have anticipated what the engineering fraternity would do in the way of producing steam haulers of greatly augmented power or what the coach and carbuilders would do in the fabrication of heavier, larger and much stronger vehicles. Every mile added to the speed per hour and each ton of amplified load, as time went on, was inevitably bound to increase the operative burden to be borne by the inconspicuous brakes; and the problem laid upon the shoulders of Westinghouse, as long as the air brake was the subject of his intensive study, was to make his apparatus better able to meet the changing conditions imposed by traffic demands and the ceaseless development of railway rolling stock.

His "straight air brake" of 1867, which applied restraining pressure to the wheels by means of air fed directly from a reservoir on the engine, had one outstanding weakness—control was lost if any of the cars became detached through accident. Therefore, in 1872, Westinghouse produced his "plain automatic brake," which was designed to apply instantly the brakes on every car, should the train units become separated through any cause. That invention became the basis of the extremely flexible and ingenious apparatus since brought into being for the retarding and stopping of trains of all kinds. If a train breaks in two today both sections are quickly halted, owing to the compressed air stored in an auxiliary tank beneath each car and to the action of that mechanical marvel, the "triple valve."

As Westinghouse planned, his triple valve stands sentinel between the auxiliary tank and the brake cylinder, on the one hand, and the auxiliary tank and the "train pipe" on the other, by which compressed air is primarily supplied from the locomotive. In order to prevent the auxiliary tank from feeding air to the brake cylinder when such action is not desired, it is essential that a certain pressure be maintained continually in the train pipe. If this equilibrium be destroyed purposely by the engineer or by the parting of the train, then the auxiliary tank dominates the situation and applies the brakes. It should be evident that the air pump on the locomotive must also function automatically whenever the air in the train pipe approaches the minimum prescribed pressure, for, if it did not, leakage anywhere in that part of the system might induce a gradual, if not a sudden, setting of the brakes—in one case adding to the drag or load upon the locomotive and in the latter causing an abrupt and possibly harmful halt.

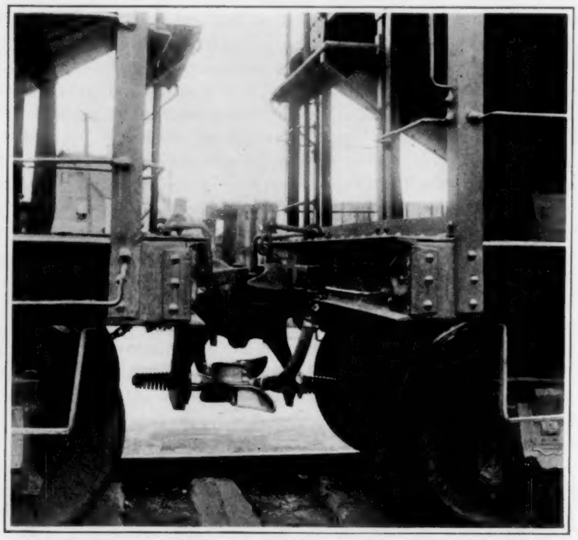
The automatic air brake permitted the running of longer, heavier, and faster passenger trains, and soon was adapted to freight service. As the years went on, Westinghouse successively improved his braking apparatus to meet the restless advance in railroad engineering and operative practices, but there came a time in the "nineties" when his rare inventive cunning was diverted to other mechanical problems. Then it was that Walter Victor Turner came forward to carry on the vitally necessary work of perfecting and widening the scope of compressed air's part in exercising train control. Turner was, in fact, inspired by accident to pursue the line of endeavor which has made his name famous.

Turner was born in England in 1866, where he was trained for the textile industry, but came to the United States and in 1893 engaged in wool growing in New Mexico. While in search of a runaway flock of sheep he happened upon the wreck of a freight train, and obtained a triple valve which had been cast aside from the damaged brake equipment of one of the cars. Afterward, by candle light, he studied that mechanism in his spare hours, and his imaginative mind grasped the potentialities of the art of train braking. When his venture in sheep raising failed, after a few years, he se-

TWO CARS COMING TOGETHER—BOTH CARS AND THEIR HOSE BEING COUPLED AUTOMATICALLY

cured employment as a car repairer with the Atchison, Topeka and Santa Fe Railroad, and it was not long before he was actively engaged in overhauling air brakes and even in devising ways to better them. To make a long story short he was "loaned" by the Santa Fe road to the Westinghouse Air Brake Company in 1903, where his rise was rapid.

Between 1903 and January, 1919, when he died, Turner accomplished some remarkable things. He brought out, among these, the well-known "K triple valve," designed especially to facilitate the safe operation of long freight trains. Prior to the advent of that invention, the running of trains of fifty cars was deemed the limit, but his valve made it quite practicable to handle trains composed of from a hundred to a hundred and twenty-five cars. Further, he designed braking apparatus that would enable an engineer to stop his "special," speeding along at sixty miles an hour, within a stretch of a thousand feet, where double that distance had been needed previously to halt lighter passenger trains. The results obtained by Turner were due to the way in which he overcame the sluggishness of the pressure-drop in the train pipe which had hitherto prevented the well-nigh instantaneous application of the brakes upon all of the cars of a long train. That is to say, the brakes would be set on the cars near the locomotive five, ten and fifteen seconds before those on the rear cars would be called into action. As a consequence, when going down hill, the unchecked vehicle would surge violently forward and crash against the cars ahead. Or, when starting or when gathering speed, after slowing up, the wheels on the front cars would be free to revolve while those farther back would still be gripped by the brake shoes. This drag frequently caused trains to pull apart.



AUTOMATIC CONNECTOR INSTALLED FOR FREIGHT SERVICE
There is only one line of hose used—that carrying air for the brakes

By reason of the improvements made by Turner, freight trains of large capacity could be hauled with safety not only up grade but they could be controlled with greater certainty when descending a steep slope. It would be difficult to do full justice to Turner's inventiveness and to the manner in which it stimulated the tide of transportation and the carriage of a vastly increased tonnage of manufactured commodities and raw materials, but it can be said without fear of denial that rail traffic today would be woefully hampered if he had not devoted his rare genius to making the air brake a more positive and flexible medium of train control.

Despite all that Westinghouse did in producing and in enlarging the capabilities of the air brake, and notwithstanding what Turner accomplished subsequently, one feature of the automatic air brake system has held its own for the most part unchanged during the years of evolution under discussion, i.e., the manner of coupling the train-pipe hose between cars. True, this is no longer as crude as it was in the early days when these rubber links were joined by a "butt end" contrivance, consisting of a "male" and "female" element which screwed into each other, and required a duplication of these features beneath both platforms of every coach.

But, even so, the air-brake equipment still employs rubber hose between cars in order to unite the several metal pipes that form the air-distributing system, and these hose lengths must be coupled and uncoupled by hand. Needful as they may be, they are nevertheless weak links in the arterial arrangement by which energizing air is circulated from the main reservoir, on the locomotive, to the very end of a train and through which the impulse is dispatched which summons the separate auxiliary tanks into action. If they leak, if their junctures are not tight and the air finds a way of escape, the intended working of the brakes may be seriously impaired. How? To begin with, it may be impossible, for this reason, to charge to the desired pressure the numerous auxiliary reservoirs located from front to rear of a train; and, what is more, leakage in the hose may prevent the maintenance of a sufficient pressure from end to end of the dominating train pipe. Besides hampering control and thus limiting the number of cars that can be effectively braked when the engineer moves the lever for a service application, this deficiency may invite a disaster when an emergency application, intended to bring about a stop in the shortest distance practicable, is demanded. Again, a leaky hose or coupling may cause the brakes to apply gradually, "creep" as it is termed, without the engineer being aware of the fact until the drag slows up the train or perhaps occasions a break-in-two. Finally, if a hose should burst—a not uncommon mishap—the train may be abruptly and even destructively brought to a standstill. This is inevitable if the rear cars hurl themselves upon the vehicles first arrested.

One fruitful cause of trouble with the linking hose lengths is the failure of trainmen to see to it that these connections between cars are properly made. The demand for quickness in assembling trains and then in detaching and distributing the vehicles later on, gives rise to a measure of carelessness—the railway operatives expecting the couplings to adjust themselves or to disconnect, as the case may be, after somewhat incomplete handling. Undoubtedly, a goodly measure of this hasty manipulation is bred of the fear of bodily harm to which the men are exposed when getting between cars to make or to break the connections of the air hose.

As the use of the air brake widened to meet transportational needs, the objections to hand coupling of the hose multiplied. The inventive skill of the country sought to provide remedies or substitutes; and the United States Patent Office holds abundant proof of the many efforts which have been made to do away with the manual adjustment of these conduits. Millions of dollars have been spent in this quest, for experience made it plain that much might be gained could the air hose be connected and disconnected automatically. In most cases, the primary purpose of the attempted improvement was to facilitate the making up and the breaking up of trains—thereby saving much valuable time; the second aim was to obtain uniformly tight connections; and the third goal was to do away with the need of having yardmen and trainmen get between cars where they were likely to be hurt.

Why the swinging loops of hose have so long been employed should be apparent to anyone who has stood on the platform of a moving train and watched the oscillations of the neighboring cars. As the tracks undulate in following the contour of the roadbed, the contiguous platforms rise and fall more or less oppositely—this play amounting to several inches. Likewise when the train sweeps around a bend, the vehicles surge from side to side—the movement of each car being independent and of a varying dgree, according to the sharpness or to the amplitude of the curve. Plainly, the train-pipe links must be

flexible in order to accommodate themselves to the continually changing motion.

It was because of these conditions, and the difficulties therefore of making an air-tight joint, that so many inventors in this field of railway equipment were baffled. Their apparatus would not give and take sufficiently and, at the same time, maintain air-tight and steam-tight connections. Further, the opposite ports of their devices would not always meet and seal properly when the cars were brought together on a sharp curve or upon a pronounced gradient.

Recently, however, a coupling has been developed that appears to surmount all these several obstacles. It is the invention of Joseph Robinson. He so forms the head of his connector, and the support by which it is carried, that a very considerable difference of alinement can be taken care of. As shown in the accompanying engravings curved "gathering prongs" serve to bring opposing heads to an exact center—port to port, where they remain in intimate contact no matter how the cars may lurch or undulate or surge or pull away from one another when train slack is bunched or stretched in transit.

Tests under the most trying conditions—those purposely designed to tax the apparatus to the utmost—have failed to exceed its powers of accommodation. The reason for this is that each connector unit is suspended upon a universal joint which is so designed as to absorb completely all service shocks and stresses that might tend in any way to destroy the tightness of the joint between the mated heads. At the outset Robinson was frequently told that rubber would never do for the steam port of his connector. He was cautioned that his material would soon wear out and involve repeated replacements to prevent leakage. Further, by way of discouragement, his critics were frankly skeptical about getting tight joints at any time.

Opposition acted as a stimulus, however, with the result that he devised a molded rubber gasket of a very durable compound. This he placed in a supporting annular recess at each port in the connector head so that the front surface of the gasket would come against that of the corresponding gasket just before the joining connector heads were brought metal to metal. The arrangement is such that this union, already under pressure, becomes still tighter the moment air or steam flows through his equipment. Service experience has demonstrated the long life of these gaskets and has emphasized their conspicuous efficiency.

Leakage in the train pipe system calls for a more vigorous operation of the air compressors and hence entails a greater consumption of coal, the cost of which amounts to from seven to eight million dollars per year in the United States alone.

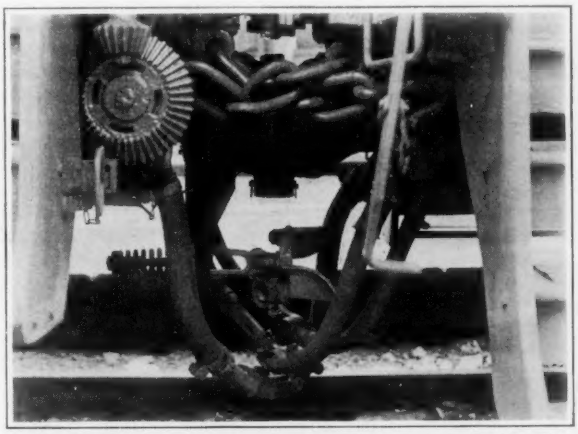
The common brake-hose coupling, provided its packing rings are in good condition and the connection is properly made, will function satisfactorily unless affected by frost. The cold weather of winter tends to stiffen the hose and, instead of yielding without stress to the vibrations transmitted by the cars, nearly all of the motion is centered at the coupling, which is worked somewhat like a hinge, thus causing the escape of the compressed air. For this reason, it is next to impossible to haul full-length trains in the more frigid parts of our country during the winter months: and this means that the number of cars which a locomotive can ordinarily handle must be greatly reduced—often as much as forty per cent. This is indeed a serious matter, especially when the demands upon the railways call for the fullest movement of freight. Further, the frost-stiffened hose cannot be readily coupled and uncoupled by hand, and the time lost in this way adds heavily to terminal charges. It is not at all uncommon, for these reasons, for freight trains to be delayed many hours in getting out of the yards when exposed to severe winter weather.

The new connector functions positively and well under all climatic conditions; it is unaffected by snow or ice. Not the slightest leakage occurs even when the thermometer registers 60 degrees below zero. It is necessary only to bring the cars together to connect the train hose automatically, and, similarly, the drawing of the cars apart automatically separates the device. There is no occasion for railway workers to risk life or limb by getting between the cars to couple or to uncouple the hose. This service on our roads, now generally necessary, occasions yearly the death of scores and the injuring of hundreds among train crews and yardmen.

There is still another loss. Much damage is done to the air-brake system, itself, by neglecting to disconnect the present hand-operated couplings before detaching cars. Not only are the hose lengths in this way ruptured or their fabric weakened so that they burst when least expected, but the metal piping on the cars is apt to be broken or impaired and leaks induced. The automatic connector, by reason of the way in which the hose is joined to it, protects the latter and does not subject it to any mechanical wear or harmful stresses. Therefore, hose that would ordinarily last but a maximum of eight months, will give a useful life of something like three years! Just what this represents can be gathered from the fact that our railroads now spend every twelve months substantially ten million dollars for air and steam hose.

In the popular mind, the automatic connector may not loom large when compared with the somewhat complex and diversified features of the breaking equipment generally, but the railroad man will readily appreciate what the apparatus represents as a dependable substitute for a weak link in a system of control which year by year becomes more and more important in the safe, efficient, and gainful operation of American railways. In the course of the last six years the automatic connector has covered over three million train-miles in Canada alone, where it has met every service need under the severest of climatic conditions, and, accordingly, the use of the connector is being widely extended.

Strange as it may seem, every bit of engineering progress that has given us more powerful steam locomotives, that has called into being longer and more ponderous trains, has come about with little if any regard to the added burdens which these changes were bound to impose upon the braking apparatus. The advent and the rapid development of the electric locomotive are hastening the coming of the day when splendid passenger trains, starting from a standstill, may be accelerated to sixty miles an hour within the amazingly brief interval of a minute of time. Then, even more than now, must the man at the lever have every confidence in the braking system at his disposal. Each second must be made to count in arresting that tremendous momentum so that the thunderous mass can be halted quickly if peril threaten. Here it is that the automatic train-pipe connector is destined to play an important and essentially vital part.



THE INTERCHANGE DEVICE WHEREBY A CAR THAT HAS THE AUTOMATIC CONNECTOR MAY BE LINKED WITH ONE NOT SO EQUIPPED

DE HAVILAND TWO-SEATER MACHINE FITTED WITH THE NEW HANDLEY PAGE WINGS

Slotted Airplane Wings*

A New Form of Wing of the Venetian Blind Form

INNUMERABLE proposals have already been advanced with the object of improving the aerodynamical properties of aeroplane wings. Up to the present, however, real improvement has been effected solely by varying the conventional wing section. Wings with radically unconventional sections—such as the doubly-cambered upper surface wing applied to the "Wight" seaplane exhibited at Olympia in 1914—have been tried and abandoned. Others have proposed or tried various forms of cellular wing constructions ranging from simple box-kite arrangements to devices resembling a magnified honeycomb radiator. Some of these wings have succeeded in developing "lift"; others have not, and all, we believe, have passed to the scrap heap. Other inventors, again, have been attracted by the idea of arranging two or more wings in tandem. As a more or less logical development of this idea, the Venetian-blind wing has been proposed and tried scores of times, more frequently, in all probability, than any other one form of wing. In view of the innumerable trials and failures with this type of wing in the past, it is distinctly startling to find that, disguise it as we may, the new Handley Page wing, about which so many rumors have been heard, turns out to be of the Venetian blind or slat wing form. Mr. Page and his experts will perhaps not agree with this description of the new wing, but as their own illustration, which we reproduce in Fig. 1, should make clear, no other simple approximate designation can be suggested.

In 1909, Zerbe produced a machine—to be found illustrated in the earlier editions of Jane's "Aircraft"—in which each wing was composed of six tandem sections slightly overlapping, the trailing edge of one section overlying the leading edge of the section behind it. The sections were lenticular in end view, and the free passage between an adjacent pair was considerable. With the exception of the difference in the sectional form of the cross slats and a difference in the angle at which the wing as a whole was arranged, the system was substantially the same as found in the new Handley Page wing. We mention Zerbe's wing system especially, but we are well aware that hosts of other pioneers might be claimed to have forestalled Mr. Page.

The fact is, of course, that the virtue of Mr. Page's new wing lies not in the adoption of the slat principle, but in the form given to the section of the slats and of the passages between them and the overall assembly of the slats to make the complete wing. The general structure may be described as consisting of an ordinary wing of accepted section through which is formed a series of passages parallel with the leading edge. The form given to the passages has been a matter of prolonged, painstaking research, but the principles governing the final selection cannot be stated further than by saying that the gap between the walls of the passages decreases from the mouth to the exit.

So far, the results of laboratory tests are alone available in connection with fully slotted wings of the type shown in Fig. 1. These tests, we are assured, have established the fact that the slotted wing develops a very much greater lift per square foot of its surface than an ordinary wing, the increase being of the order of 200 to 300 per cent. Wings with but one slot near the leading edge are stated to show about 55 per cent more lift than similar wings without slots.

On Thursday of last week we witnessed at Cricklewood the ascent, flight and descent of two De H 9 two-seater machines, one with ordinary wings, the other with the ordinary wings modified with a slot at the leading edge, as shown in Fig. 2. The modified wing may be described as consisting of the original wing with its leading edge brought back from the point A to the point B, leaving the ends of the wing ribs exposed as at C, and with the outline of the section restored by means of a metal-covered "winglet" D attached to the rib ends. The winglet, it is to be understood, was definitely fixed

*Reprinted from *The Engineer* (London), Oct. 29, 1920, p. 42.

to the ribs; it could not, in the aeroplane examined, be turned about an axis so as to reduce or increase the section of the slot. The slotting was applied to both the upper and the lower wings.

On the ascent, during the flight, and on the descent of the two machines, it was perfectly obvious that the slotting of the wings had profoundly modified the aerodynamical qualities of the machine. The "slotted" machine rose at a sharper angle, climbed more quickly, alighted at a much slower speed, and pulled up in a considerably shorter distance than the other. Further, its pilot was able to fly it with its tail down—during horizontal flight—at an angle which would have "stalled" the other machine. It is stated that the machine can be flown horizontally with the center line of the fuselage inclined at nearly 45 degrees of the path of flight.

The demonstration last week suffered, from our point of view, by the fact that it was a popular one, to which all and sundry were invited. From a popular aspect it may be quite satisfactory to say that the new wing has a very much greater lift per square foot than an ordinary wing, that its lifting power is two to three or three to four times as great as that of the usual construction. From the technical and scientific standpoint, however, the statement cannot, we think, be accepted as it stands, nor do we believe that Messrs. Handley Page desire us to accept it without qualification.

It is not, we think, suggested that of two wings, one slotted, one plain, the slotted wing will develop two to four times as much lift as the plain wing when both wings are set with their chords at the same angle of incidence, and are moved at the same speed. Nothing that we have heard or seen implies such a claim, and until it is so advanced we shall prefer to look at the matter in a somewhat different way.

An ordinary wing set at the usual small angle of attack can be made to develop two or three times the normal lift by increasing the angle of attack, provided the wind-speed is maintained constant. The trouble is, however, that as the lift increases so does the drag or resistance. Hence, in an aeroplane with a strictly limited output of energy from the engine, the effort to increase the lift by increasing the angle of attack is defeated by the inability of the engine to maintain the speed against the increased drag. The speed falls, and, as a consequence, the lift decreases. The limiting condition is reached when the increase of lift derived from the increased angle of attack is just balanced by the decrease of lift produced by the enforced reduction of the speed. The machine in this condition is on the point of "stalling," and is in danger of falling or executing a tail slide. In the new Handley Page wing, we suggest, the construction is such that it is possible to fly with the tail of the machine down in an attitude quite beyond the reach of an ordinary machine. In this attitude the lift is increased, as it would be in the ordinary machine if the same attitude could be reached, but the drag is not increased or not increased to the same prohibitive extent, and is still within the ability of the engine to overcome. Looking at the sketch of the wing, it will, we think, be agreed that this result is what we should expect, and that as the angle of attack is increased it is possible even that up to a point the increase of lift may actually be accompanied by a decrease of drag. We suggest, then, that the curve of lift against angle of attack for the new wing will not be found to reveal anything much out of the usual, but that the curve of the drag at various angles of attack is distinctly out of the ordinary. It is a case, in short, not so much of increasing the lift at any given angle of attack, but rather of decreasing the drag.

Whatever may be the exact explanation, it seems certain that the new wing represents an important step in advance. It clearly permits the machine to which it is fitted to fly at very low speeds relatively to those hitherto regarded as the minimum, for it enables the pilot to place his machine in an attitude which permits him to work on a portion of the lift curve quite beyond the reach of the ordinary machine. In actual flight, of course, the problem is not to increase the total lift, but to maintain it, at all speeds, constantly equal to the weight of the machine. With the higher portion of the lift curve made available by the new wing, it is obvious that the total lift can be maintained by dropping the tail and reducing the speed. It is not to be supposed that passengers will relish traveling at a low speed with the cabin sloping downward toward the tail at angles up to 45 degrees. The journey will, as at present, be executed at high speeds with the fuselage horizontal—if necessary, by providing means for varying during flight the area of the slots in the wings. During descent or ascent, however, the slots will be opened with the result that slow landing speeds and ascents at sharp angles will be possible. The inclination of the fuselage to the path of descent or ascent will just about equal the inclination of the path to the ground surface, so that during the descent or ascent, the

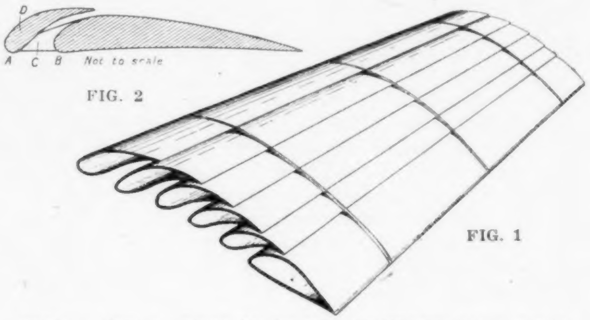


FIG. 2

FIG. 1

FIGS. 1 AND 2. DETAILS OF THE HANDLEY PAGE WING

center line of the fuselage will remain substantially horizontal. Alternatively, the new wings may be built on to the machine at much larger angles than hitherto used. In this case the required lift will be obtained with wings of reduced area. The horse-power required to drive the machine at a given speed will be less, or with the same horse-power the lift may be increased and the extra lift be utilized to carry wings of greatly increased weight and strength.

INTERNATIONAL AIRSHIP NAVIGATION

WRITING in *Revista Marittima* for June, 1920, Lieut. Gill Varoli-Piazza advocates the inauguration of airship lines radiating from Rome on account of its central position.

The routes proposed are Rome—Gibraltar—Fayal—New York; Rome—Gibralter—Paris—London; Rome—Alexandria—Cairo; Rome—Constantinople. The airships would be of two sizes, 100,000 and 50,000 cubic meters capacity, there being 8 of the former for the ocean lines and 9 of the latter for the Mediterranean lines. Allowing for an adverse wind of 5 m.s., New York would be made in 104 hours, Buenos Ayres in 156, London in 21, Cairo in 28, and Constantinople in 17. The cost of installation of the lines, including ships, landing stations, hangars, etc., is estimated at 145 million lire, and the cost of running and maintenance at 111 million per annum.—Abstracted by *The Technical Review.*

AIRCRAFT IN THUNDERSTORMS

WRITING in *Illusrierte Flug-Welt*, Aug. 4, 1920, Major D. Carganico discusses the possibility of airplanes in flight being struck by lightning during a storm, basing his arguments on test flights under such circumstances.

He shows that no danger is to be expected if the machine is not in the direct line of a discharge, and even if it is, it is not likely from the nature and distribution of the conducting metal portion that danger due to fire will arise. Out of 30 cases where the machine was struck directly the writer maintains there were no evil effects, while in all known cases in Germany where a machine fell during a storm there was no evidence of scorching of parts or melting of metal.—Abstracted by *The Technical Review.*

Weather Conditions and Flight*

Climatological Factors Governing the Selections of Air Routes and Flying Fields

By C. Le Roy Meisinger

THERE is, it seems, a vagueness in the opinions of many people regarding the value of meteorology in the selection of air routes. One reads of "pathfinding" and of "charting" flights by which it is implied that a single journey or, at most, several journeys over a proposed course will afford sufficient data to designate that route as satisfactory or unsatisfactory for continued use. Such reasoning is unsound. It is obvious that the aerial medium is possessed of such a host of variable attributes, that the conditions which one finds today may not occur again in precisely the same combination for months or even years. Of what profit shall it be to measure the temperature, humidity, and other elements, in a single flight, unless it be that these data are to be used in the discussion of the flight itself, relative to the performance of the motor or instrumental equipment, the physiological reaction of the travelers, or in one or more of the several other problems that may take the form of special tests? If such observations are to be made, they should be made over a wide area, by numerous craft, and as nearly simultaneously as possible. The ocean of air is far from being a fixed thing. Perhaps the likening of the atmosphere to the aqueous ocean is a figure of speech which has been somewhat overdone, and has resulted in the popular conception of aerial currents as fixed as the Gulf Stream or the Japan Current. It is also possible that the pioneer work of Rotch and Palmer, *Charts of the Atmosphere for Aeronauts and Aviators*, which appeared in 1911, did not lay sufficient emphasis upon the pitfalls of too great reliance in averages. Our atmosphere is not made up of great permanent streams and currents, and even our conception of prevailing westerly winds aloft is sometimes shocked by the spectacle of cirrus clouds moving from the North, East, or South. Therefore, efforts to lay down definite airways without reference to the fundamental conditions which really determine desirable routes cannot prevent themselves being relegated to a position of slight importance. It would be unfair to assert that any carefully made scientific observation is of no value; but it is obvious that, in such matters as the selection of air routes, other factors than such observations must be considered before one can legitimately make generalizations upon so subtle a medium as the atmosphere.

THE SELECTION OF ROUTES

It is self-evident that the point of departure and the destination must determine the general direction of flight. But it is by no means axiomatic that the air route shall follow a straight line between these two points. Irregularities of the terrain, its physical characteristics, and the weather along the route must, in the last analysis, determine the course of the aviator, if he is to cover the distance with the greatest economy of time and fuel. In brief, it is the geography and the climate of the region between two stations which must determine the approximate route, but the weather at the time of flight must determine the details of the aviator's course.

While the fact is recognized that a single condition may not be representative of the weather over a given route, and also that mean conditions over the same route may differ greatly from the conditions of any particular day, it is believed, nevertheless, that the best basis for laying out a preliminary route between two points lies in the mean values of certain climatological and aerological factors.

Wind.—Perhaps the most important of all the weather elements to the aviator is the wind. It is necessary in commercial aviation to take advantage of any conditions which will aid in economy of time or fuel or will be conducive to greater safety. If, then, the "pathfinder" is to live up to his name, his first concern must be to determine the speed and direction of the prevailing winds over the proposed route. These winds should be determined, not at the surface alone, but to as great altitudes in the free-air as possible. Moreover, it is very likely that he will discover that certain elevations will, in the long run, be more favorable for flying in one direction, and that other levels will be more favorable for the return journey. Rouch and Gain[1] have shown how important such wind studies are in regard to flying in Northern Africa. The journey from Oran to Tunis, they find, should be made at an altitude of about 2,000 meters, because at this elevation a strong westerly wind prevails. The return journey, in the long run, will be made most profitably at an altitude less than half as great, because the westerly wind at that elevation is greatly diminished in force. Such prevailing winds should be determined from as long records as are available and should be worked out for small time units; seasonal averages would be valuable, but monthly means would undoubtedly be better. Not less valuable in this connection are the means of diurnal wind changes, both in speed and direction. In fact, each additional factor brings the conditions nearer to those which the aviator is likely to encounter in flight.

Digressions from the great circle[2] path between two points would be most helpful in cases of high winds and relatively slow-moving craft. Thus, a high-powered airplane flying at 110 miles per hour in a gentle wind would gain little, if any, by departing from the great circle. But a dirigible, on the other hand, moving at 60 miles per hour, might find it very much to its advantage to follow the general direction of wind flow if the wind speeds were quite high and if the curvature of the wind path were such as eventually to bring it near its destination. Thus, the gain to be made by departing from the great circle becomes smaller and smaller as the ratio of craft speed to wind speed becomes greater.

Cloudiness and fog.—The influence of the lower clouds and fog upon flying is very great. As a rule, it is essential to retain sight of the earth. When there are low clouds and fog, however, to keep in sight of the earth is obviously a hazardous proposition. The disadvantages of low flying when there is a cloud layer quite close to the ground have been set forth by Prof. B. Melville Jones,[3] as follows: 1. Strain to the pilot, owing to constant bumpiness, poor visibility, and proximity to the earth. 2. Danger of collision, occasioned by poor horizontal visibility. 3. Discomfort to pilot and passengers, since flying above clouds is exhilarating. 4. Choice of altitudes is limited, and therefore it is difficult to select advantageous flying levels. 5. Annoyance to people on the ground. 6. Danger in case of forced landings.

While Prof. Jones inclines to the view that overcloud flying has advantages over undercloud flying when the clouds are low, he does not hesitate to point out the danger and discomfort occasioned by having to ascend to great heights to clear clouds; moreover, it not infrequently happens that the cloud layer is thick, or that there are several layers. The danger of flying in clouds is great, not only because of the possibility of loss of sense of balance by the pilot, but because the clouds

*From the *Monthly Weather Review,* September, 1920, pp. 525-527.

[1] Les cartes des vents à l'usage des aéronautes. *Revue genérale des Sciences,* March 30, 1919, pp. 168-171.

[2] It is so customary to think of the earth's surface as it appears on a flat map that the fact often is lost sight of that the shortest distance between two points on a spherical surface is the arc of the great circle upon which the two points are located. This applies chiefly to long distances and is used by mariners; but it also applies in the case of long aerial routes.

[3] Flying over clouds in relation to commercial aeronautics, *Aeronautical Journal,* May, 1920, pp. 220-249.

may reach the ground without his knowledge, thus making a crash likely when attempting to land or descend to lower levels.[4] There is also the danger of being unable to find the landing field at the end of the flight and the difficulty of navigating without visible points on the earth. Whatever may be the advantages of overcloud flying, there is no escaping the fact that low clouds are a menace to the airman.

It is therefore necessary in the laying out of proposed aerial routes to consider carefully the frequency of low clouds and fog. Bodies of water, such as lakes, rivers, and the ocean, as well as cities and deserts, often contribute to the formation of fog and the production of low visibility.

Thunderstorms.—To the pilot of heavier-than-air craft no less than to the pilot of lighter-than-air craft, the thunderstorm is a formidable enemy and one to be studiously avoided. The few who have ever penetrated the interior of a thundercloud have suffered experiences which they would not care to repeat, if, indeed, they have come through alive. Dr. Charles F. Brooks has discussed several instances in which aviators have described their experiences in or near thunderstorms.[5]

Lighter-than-air craft are forced into the uncomfortable situation of having to land, or attempt to fly above, or around, the thundercloud, any or all of which may be extremely difficult. In the case of a dirigible balloon, it may be possible to fly around the storm as an airplane might do, and thus succeed in avoiding it. The alternative of landing in the face of the oncoming storm with its squall wind is not desirable because of the difficulty of handling the balloon on the ground. To attempt to fly over a towering thunderstorm may be entirely out of the question owing to the excessive altitude which would have to be attained, for great altitude necessitates unpleasant physiological effects and the loss of gas (through expansion) and ballast.

It is true that usually the thunderstorm is essentially a local phenomenon, which may attend the passage of the wind-shift line in a LOW or may be formed locally by strong convection. Thus, the chances of encountering thunderstorms during a given trip are very much dependent upon current general conditions. But the frequency of occurrence of thunderstorms along a given route is a thing that it is vitally important to know. For one may discover that in certain months in a given region the thunderstorm frequency is so great as really to endanger the maintenance of schedules. An aircraft corporation may discover by such statistics that their craft will be placed in great danger by maintaining routes through regions of great thunderstorm frequency. The wisest course in those cases might be to modify the schedule during those times, to select new routes, or to discontinue service in that region temporarily. Again, this knowledge can give some clue to the possibility of profitably modifying the administrative activities of the corporation, such as shifting the personnel of flying fields, distributing equipment, extra parts and supplies. All of these factors will have their reflection in direct financial returns. A blind indifference to the statistics of climate over air routes is, therefore, a narrow business policy, and that corporation which manifests this indifference is the one which, no matter how skilled its pilots, will find its dividends dwindling because of loss of equipment through accidents and consequent loss of popularity with the public.

Temperature.—The knowledge of mean temperatures over routes is perhaps the least important of the weather factors. It is true that temperature has a profound influence upon the maintenance of schedules in extreme weather. But with the improvement of aircraft engines so that they function at extremely low temperatures, and with the electrical heating of the cabins of passenger-carrying planes and dirigibles, the influence of the temperature factor is appreciably lessened. Information regarding average vertical distribution of temperature and of the diurnal change of this distribution is helpful. Unfortunately such data are somewhat limited, but the Aerological Division of the Weather Bureau is conducting a study of a great number of kite flights which will probably supply to a large degree this need. The knowledge of mean vertical temperature distribution is not as important in the preliminary laying out of air routes as in the discussion of the current data supplied to the aviator just before he ascends.

Humidity and precipitation.—These elements are not of great importance at the outset, and they are so interwoven that their value depends chiefly upon the interpretative ability of the consulting meteorologist at the flying field.

THE SELECTION OF FLYING FIELDS

The problem confronting the person whose duty it is to select a flying field is not an easy one; or, at least, it is one that cannot be rightly solved by a mere consideration of the civil or military requirements. Today, with the multitude of flying routes being established, it sooner or later becomes the problem of the commercial clubs or chambers of commerce in most large cities to determine a landing field in the immediate vicinity. These fields have a great commercial value to the city. It is not denied that many of the local aspects, such as the availability of property, accessibility, etc., each peculiar to a given locality, rightfully have a foremost place in the consideration. But the meteorological aspect can not be neglected, for it is conceivable that, in spite of a hundred desirable features of a landing field, there may be certain characteristics which, from a meteorological standpoint, will render it utterly unfit for the purpose. Again assuming the climatic features to be favorable, the field itself must be so laid out that it will serve most efficiently. That is to say, for instance, that the long axis of the field, if it be small and rectangular as many are, should lie in the direction of the prevailing wind at the place, because it is necessary that planes land heading into the wind and that they also rise in a headwind. The buildings should be so oriented and distributed as to interfere the least with landing or rising planes, and where the eddies and gusts they cause will not interfere with craft flying low over the field.

A very striking example of the consequences of neglecting the meteorological aspects is given by Rouch.[6] During the war, the British desired to establish a training field for aviators for bombing instruction, and a commission was appointed for the purpose of determining the location. The shore of Loch Doon, in Ayrshire, was chosen. After the work of establishing the field was well along, the hangars were being built, a railroad was contracted for, and other expensive arrangements had been made, it was discovered that the neighboring hills gave rise to eddies and squalls which absolutely prevented safe flying at that place. The field was abandoned with a loss to the Government of upwards of $2,000,000. In conclusion, Rouch says, "The installation of some instruments and the consultation of some tables of figures would have permitted 12 million francs to be saved. In that circumstance, sadly writes the *Times* (London), the authorities did not perform their duty." It is unnecessary to emphasize the import of this example.

The Air Service recognizes the tremendous importance of the climatological considerations in the selection of flying fields.[7] To quote from the circular which discusses this question:

"The number of flying days to be expected in a year or in

[4]The writer had such an experience in a free balloon. Having ascended into a rather low layer of clouds and having lost all sense of direction, the party was surprised to discover several hours later that the trail rope of the balloon was dragging on the ground. The low clouds had actually reached the surface. For full account, see "A free balloon flight in the northeast quadrant of an intense cyclone," *Monthly Weather Review*, April, 1919, 47 : 233-235.

[5]The effect of wind and other weather conditions on the flight of airplanes. *Monthly Weather Review*, August, 1919, pp. 523-532. See also Meisinger, C. LeRoy: A balloon race from Fort Omaha through thunderstorms, idem., pp. 533-534.

[6]Préparation météorologique des voyages aériens. Paris, 1920, pp. 53-54.

[7]Meteorology and Aeronautics. *Air Service Information Circular*, May 12, 1920, Vol. 1, No. 77.

any month may be fairly well determined from a study of the climatic factors. . . . It is also possible from this study to arrive at a fairly definite conclusion as to the accessibility of the field by aerial routes for different types of aircraft. In other words, one may determine the sort of aerial harbor, ease of entrance, exit, and other things considered which aircraft would find at a given field. . . . The prevailing wind and storm directions largely determine the layout of a field. The number of days to be expected when the wind speed is too high for the operation of aircraft may be closely determined. Also the number of days with excessive precipitation, with fog or storm to be expected, may be closely approximated."

The weather factors to be taken into consideration are quite the same as those which may determine aerial routes. Precipitation comes in for greater consideration in the case of landing fields. A plane can not land or take-off readily on a muddy field, and a snow cover demands the greatest attention.[8] As the Air Service circular points out, topography and wind are inseparably bound together in relation to aeronautics. The effect of wind blowing over a rough terrain is to produce rugh air in which to fly. Landing fields in a hilly region are especially apt to be dangerous; and the proximity of trees and high buildings is likely to cause roughness extending to a height three or four times as great as the object. This is dangerous to a plane slowing down for a landing or for slow-flying planes.

CONCLUSION

An effort has been made to present the vital importance of meteorological studies in connection with the establishment of aerial routes and the layout of flying fields. The argument does not pretend to overstress the use of averages in connection with such work, but it does attempt to emphasize their importance in the preliminary work. Meteorology is the mainstay of aviation regardless of the confidence of the aviator in his motor and its ability to carry him safely over all obstacles. The dirigible has inspired us with a confidence in its future as a commercial transport; the aerial mail has definitely stamped the airplane as a reliable means of rapid transportation of mail, baggage, and passengers. Great aerial corporations are being organized. They are commercial enterprises, highly capitalized and founded for the purpose of paying dividends to their stockholders. Dividends depend upon the skillful management of the assets of the company, the reduction of the expense of maintenance, the extension of routes into the most profitable places, the acquisition of the public confidence. Every accident is detrimental to the cause of aviation, not alone because of the direct financial loss, but because it weakens the public confidence. The record of the Aerial Mail Service shows that the weather is responsible for the greatest number of accidents and forced landings.[9] Many of these could be avoided by giving the weather its due consideration. Here is one of the places where the consulting meteorologist is urgently needed.

THE PREDICTING OF MINIMUM TEMPERATURES

THE Journal of the Washington Academy of Sciences for July 19, 1920, contains an account of a paper presented by Mr. J. Warren Smith before the academy.

This paper was a discussion of the relation between the relative humidity in the late afternoon and the variation of the minimum temperature during the coming night from the afternoon dewpoint temperature, when radiation conditions prevail. The study shows that there is a well-defined relation which can be expressed by the curve for a parabola. This curve can be constructed by the "star point" method of curve fitting instead of by the more tedious well-known least square method.

The equation used is written $v = x + by + cz$ in which v is the variation of the minimum temperature from the evening dewpoint; b is the evening relative humidity, and c is the square of the relative humidity. x, y and z are the three unknowns, which are evaluated from three normal equations which are readily written by the star point method after the data have been properly charted. The results are remarkably accurate. The studies show that the minimum temperature can be closely predicted in the orchard at a considerable distance from the observing station; that the hygrometric observations made at noon may be used quite as well in some instances as those made in the evening, and that the equation will sometimes apply as well to cloudy as to clear nights.

By using the depression of the dewpoint instead of the relative humidity in correlating with the variation of the minimum temperature from the dewpoint there is, in some instances, an even closer relation shown. In this case a straight line from the equation $v = x + yd$ fits the data fully 89 per cent of the time. In this equation d is the depression of the dewpoint, v is the variation of the minimum from the dewpoint, and x and y the two unknowns.

CHARCOAL METHOD OF GASOLINE RECOVERY

IN the September number of *Chemical Age* (New York) a discussion of the charcoal method of gasoline recovery is presented by G. A. Burrell and associates. It will be recalled that about three hundred million gallons of natural gas gasoline will be produced during this year by compression, refrigeration, and absorption methods applicable to casing head gasoline with oil absorption in the case of so-called dry gasoline. Various combinations of these methods have been employed and occasionally difficulty is experienced in marketing the product from oil absorption or compression plants because of the high evaporation losses. The charcoal process consists in bringing the gasoline in contact with activated charcoal which retains the recoverable gasoline vapors and allows the gas thus stripped to return to the distribution lines. When the charcoal becomes saturated the gasoline is allowed to come in contact with a fresh supply and the vapors are recovered from the charcoal by distillation with superheated steam. The vapors are condensed, blended and then stored preparatory to marketing. It is claimed that not only is the charcoal plant less costly to instal but that it is cheaper to operate and it produces gasoline of greater quantity and better quality than do the compression or oil absorption plants. The gravity and vapor tension of this recovered gasoline is less than that made from the same gas by either of the older processes. This is due in part to the conditions under which condensation takes place, being under atmospheric pressure only. The method by which condensation is carried on is also a factor, the charcoal process being a bath process where consecutive distillations of a series of absorbers take place instead of continuous distillations in a still. In this manner the lighter vapors are driven off first and the application of the blending naphtha to the material that actually needs blending is allowed. Thus any wild vapors in the charcoal are driven out first by the lowest temperature and do not come in contact with the gasoline which is to be sold. It is also claimed that selective absorption takes place giving clear-cut fractionation, so that the so-called wild vapors are eliminated in the absorption itself. 93 per cent of the charcoal absorption gasoline is recondensed after the standard Bureau of Mines distillation which is nearly 50 per cent higher than is the case with materials recovered by other methods.

The yield is not sacrificed at the expense of quality and a comparison between an oil absorption plant and a charcoal plant operating on gas poor in vapors show that the oil plant averaged about 125 gallons per million cubic feet of gas and had a weathering loss of 20 to 30 gallons before shipment.

[8] A note in *Aeronautics*, March 18, 1920, p. 230, tells of the addition of ski attachments to the plane where landings have to be made on snow. One of the great difficulties of landing on snow, as on water, is to tell how high the airplane is above the surface, for, with a perfectly smooth snow cover, it is difficult to judge distance; and even to know when the skis are actually in contact with the snow.

[9] Effect of weather on the Aerial Mail Service. *Monthly Weather Review*, June, 1920, pp. 335-336.

Submarine Steam Whistles*

Producing Sound Underwater by the Condensation of Steam

By Gerald Stoney, F.R.S., and Telford Petrie, M.Sc.

THE great war has undoubtedly increased our knowledge of practical acoustics. Problems affecting the location and detection of sound have had to be met and solved in the shortest possible time. The foundations of the subject, more especially on the theoretical side, had been well laid by Helmholtz, Poynting and Thomson, Lamb, and particularly Lord Rayleigh; but it was left to modern physicists such as Perrin and Walser in France and the two Braggs in England to bring listening gear, for both land and sea conditions, to a pitch of perfection that had not been previously reached or apparently been required. The sounds listened to were mostly those made by the enemy; but another phase of the subject was introduced when the detection of submerged bodies, such as submarines, was first considered. It was then thought necessary to produce a reliable and distinctive note or sound under water to be applied for this purpose. This was one of the problems to which the Lancashire Anti-Submarine Committee devoted itself; and the authors were deputed to investigate the possibilities of utilizing steam for the production of such a note.

The production of musical notes under water does not in itself seem to have received much attention in the past. Where such attempts have been made they have been devised for ulterior purposes, such as the determination of the velocity of sound in liquids. In 1826 Colladon and Sturm [1] carried out

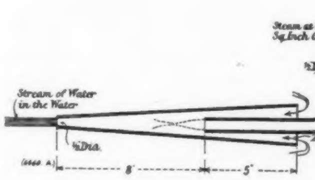


FIG. 1

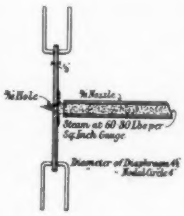


FIG. 2

their famous experiments to find the velocity of sound in water, and used a bell 70 cm. high and slightly less in diameter. This was immersed 1 m. in the Lake of Geneva and struck with a hammer. The sound was picked up 13,487 m. (9.6 nautical miles) away. In 1847 Wertheim used organ pipes for the same purpose, which were sounded by forcing a current of water through them.[2] Varying presures of this water gave varying harmonies; considerable difficulty appeared in proportioning the pipes to sound under water. In 1853 Savart [3] produced sounds by the efflux of water from tubes, a method which was used by T. Martini [4] in 1884 to determine the velocity of sound in various liquids. The tube is stopped at the bottom by a diaphragm with a small hole in it, but the note appears in the column of water in the tube and the tube does not appear to have been completely submerged itself.

With regard to the siren, Poynting and Thomson say "as a matter of curiosity we must mention the fact that the siren sounds under water if entirely immersed and driven by a stream of water" [5]—but this method did not fall within the scope of the present research, nor did the use of bells which have been developed for submarine telegraphy.

*Reprinted from *Engineering* (London), Oct. 29, 1920, pp. 561-563.
[1] "Annales de Chimie et de Physique," Series 2, Vol. XXXVI, 1827.
[2] *Ibid.*, Series 3, Vol. XXIII, 1848.
[3] *Comptes Rendus*, August, 1853.
[4] "Atti del Reala Instituto," Veneto, Series 6, Vol. IV appendix.
[5] "Text-book of Physics," Sound, 1899 Ed., bottom of page 37.

For their laboratory experiments a steam pipe, 1¼ inches internal diameter, was led vertically into a well below the condenser water measuring tanks in the authors' laboratory. This well could be flooded to a depth of 16 feet or emptied at will. The investigation started in attempts to obtain a musical note by the simple expedient of blowing steam down into the water through the central hole of a thin diaphragm which closed the outer end of a short length of the 1¼-inch steam pipe. These attempts failed even when the short length was insulated from the main steam pipe by a length of rubber hose.

Another idea was suggested by Wertheim's method already referred to; but attempts to blow organ pipes under water by steam instead of by a current of water also failed. In connection with this, it is perhaps worth recording that by taking advantage of the partial vacuum caused by the condensing steam, and fitting a funnel to the nozzle long enough to allow all the steam to condense, as shown in Fig. 1, the authors subsequently succeeded in blowing an extemporized organ pipe under water with the pure jet of water that was obtained.

The short length of steam pipe used in the first experiments was then replaced by a receiver consisting of a cast-iron pipe 4 inch internal diameter and 2 feet 10 inches long. The 1¼-inch steam pipe led into the top of this receiver and the lower end was closed by a series of diaphragms with central holes of various sizes. The whole was submerged to a depth of 6 feet. The results could hardly be called promising, but notes of between 100 and 150 periods were occasionally obtained. The frequency was measured by comparing the note in the air, as it came through the surface, with a tuning fork by ear. This method, which was only required for comparative purposes, was used throughout in the laboratory. From the fact that the notes sounded like a cow mooing, the apparatus was colloquially referred to as the "cow."

The steam pressures, as measured on a calibrated Bourdon pressure gage near the stop valve, were so low that it was doubtful whether there was not a considerable quantity of water on the inside of the diaphragm. To test the effect of a water-borne diaphragm, another arrangement was tried. This simply consisted in playing a jet of condensing steam from a nozzle on to a diaphragm under water. A soft but distinct note of about 408 periods was obtained. In order to clear the steam as soon as it had impinged upon the diaphragm, the apparatus was then arranged so that a small hole in the center of a vertical diaphragm allowed the condensing steam to impinge on its edges and escape on the far side. The note was distinct, and better than the previous one, but still too soft.

In all the methods attempted so far, the diaphragm had been clamped round its edges. The next step was taken to ascertain what the effect would be if the diaphragm were free to vibrate of itself, without transmitting its motion to the supporting apparatus. A convenient way of obtaining this was suggested by the well-known Chladni figures. In one of these a circular plate is supported on pointed corks under a nodal line and vibrated by rubbing a cord up and down against the side of a hole in the center of the plate. Poynting and Thomson give the positions of such nodal circles when one, two or three nodes are present. For convenience in clamping, the largest of the three node circles was chosen, namely, 0.894 D, and the diaphragm was supported on opposed knife edges at two points only on such a circle. The result was encouraging. A clear musical note about 600 frequency was obtained without difficulty when the conditions were adjusted as shown in Fig. 2. The repetition of this experiment in a larger tank appeared to establish the fact that the note was produced in

the water, and not, as had hitherto seemed to be the case, in the steam or by the mechanical vibration of the apparatus as a whole.

A number of experiments were then made with this form of apparatus, and the following points were brought out:

(*a*) A circular nozzle with parallel sides gave the most suitable form of jet of condensing steam.

(*b*) While notes could be obtained with various ratios of the diameter of this nozzle to the diameter of the central hole in the disc, a proportion of two to one was found to be very suitable.

(*c*) The distance between the end of the nozzle and the disc was an important factor, other conditions remaining the same.

(*d*) The proportions and material of the disc did not appear to have any controlling effect on the frequency of the note. This led to the unexpected conclusion that the note was not being produced by the vibration of the diaphragm, as had hitherto been supposed, but in some way by the condensing steam itself.

With the experience gained by the laboratory work already described, an experimental apparatus was designed. In this apparatus gear means were provided for adjusting the distance between the nozzle and the disc from above the water-level whilst the steam was on. Arrangements were made for carrying diaphragms of different sizes or discs of varying thicknesses, and also for changing the diameter of the nozzle. As a result of the laboratory work carried out with this apparatus, the following conclusions were reached

(*e*) To get a pure note the disc should be clamped on a nodal circle. This prevents the vibration from being transmitted to the remainder of the apparatus, to any appreciable extent. Subsequent work has shown that this point is not so important with small models (e. g., ¼ inch or ⅛ inch diameter nozzles), but that the greater the energy produced the more necessary it is to take this precaution.

(*f*) The note, for any given pressure (and water temperature), was not continuous as the disc was run in toward the nozzle. A high note about 800 frequency was obtained at a certain point when the distance between the two was great, and was usually held as the disc was brought in, until a second point was reached where the note changed suddenly to one of a much lower frequency (about 200). It was occasionally possible to obtain a third note, of about 100 frequency, but all three notes were not always present with similar conditions.

(*g*) The size of the nozzle, and therefore the quantity of steam passing, affected the pitch of the notes. The smaller the nozzle, the higher the note, other things being equal.

(*h*) The pressure of the steam for any given size of nozzle correspondingly affected the frequency of the notes. The lower the pressure, the higher the note.

(*i*) As far as could be checked in the confined space of the laboratory, the maximum intensity of the note appeared on the steam or nozzle side of the disk.

The apparatus was then fitted to H.M.S.T. Leonora, stationed at the Admiralty Experimental Station, Shandon, N. B., and the following trials were carried out: First of all a 4½-inch disc ¼ inch thick and ½ inch nozzle, was tried out at 300 yards, at three pressures corresponding to 105 pounds, 75 pounds and 30 pounds per square inch on the gauge on deck. An independent observer listened from the shore with a general service hydrophone (G.S.H.). All notes were loud, the best one being at the medium steam pressure. The distance was then increased to two nautical miles. (Garelochhead to Shandon.) The listener was stationed in a dinghy off Shandon, and reported no appreciable diminution in sound at that range. Both the top and bottom notes at each pressure were heard. The boat was turned broadside on for this test, but the note was also heard while the boat was steaming away from the listener at three knots.

A ½-inch nozzle was then tried with a ¼-inch hole, in a 11¾-inch diameter (½ inch thick) diaphragm. It was soon established that the larger disk gave better results. The note was obtained over a longer range of pressures and was more piercing. The best note of all was with anywhere between 60 pounds and 75 pounds per square inch on the gage with the diaphragm ⅜ inch away from the end of the nozzle. These results were then compared with a diaphragm 11¾ inch diameter, ½ inch thick, with a ⅜-inch central hole, using a ¾-inch diameter steam nozzle. The note was deeper and coarser, and the top note not so pure at short range. There seemed to be no advantage gained to make up for the extra steam used. (More than double the amount being required.)

As a result of these trials the following proportions were adopted for the subsequent work carried out with this form of apparatus. A steel diaphragm, 11¾ inch diameter and ½ inch thick, was clamped in two places on a nodal circle of 10½ inch diameter. It had a central hole of ¼ inch diameter which was tapped with a fine thread. The nozzle used was ½ inch diameter with parallel sides. This apparatus gave a powerful note with a steam pressure of from 60 pounds to 75 pounds per square inch on the gauge on deck when the distance between the diaphragm and the end of the nozzle was ⅜ inch. At first the nozzle was arranged pointing inward toward the ship. It was next pointed forward, and the ship steamed round in a circle 600 yards away. The note was heard all the time, even when the apparatus was on the other side of the ship, but was loudest when the ship was steering away from the listener. This corroborated the conclusion arrived at in the laboratory.

In further tests which were carried out in the Gareloch, the listener was stationed in a dinghy in four fathoms of water at the mouth of the loch, and the apparatus was tried out when the ship was two nautical miles away, i. e., off Shandon, and four nautical miles away, i. e., the full length of the loch: no appreciable diminution in sound was perceptible between half-way and the full distance. The medium pressure again gave the best results, and the note came through the noise of a motor launch 100 yards away from the listener. Up to the present the weather had been fine and the sea calm. The apparatus was next tried out in the Clyde in rough water. An independent observer picked up the note three nautical miles away, listening from a moving motor launch with a No. 2 "Lancashire Fish."

The longest range attempted was 11 nautical miles, when Lieutenant Dix, R.N.V.R., and Mr. Dobie, of Messrs. Cammell Laird, using a general service hydrophone, heard the note from a stationary motor launch so distinctly that the sound came out of the receiver as it lay on the cabin table. The sea was calm and the minimum depth of water between points was 16 fathoms. In this trial the ship was laying off Wemyss Point in the Clyde and the motor launch was just outside Little Cumbrae. In a test under bad weather conditions the ship was left alongside Gourock Pier and Mr. Redfern, a member of the Lancashire Anti-Submarine Committee, sailed toward Gareloch, listening with a No. 2 "Lancashire Fish." The conditions were bad, rough sea and shoals up to 1½ fathoms between. The note was heard distinctly all the time until the corner was turned into Gareloch. At two nautical miles Mr. Redfern found that he could compensate the note and gave the correct direction of Gourock from his cabin. The motor launch steamed out again and, laying off Helensborough, 4 nautical miles away, picked up the note again on a general service hydrophone.

The results of these sea trials pointed to the development of a convenient and cheap apparatus for producing a loud note under water, of considerable penetrating power. It was also found that a bar may be used instead of a circular diaphragm. Such a bar is conveniently damped and supported by a knife-edge at a nodal distance from the free end, the values of which may be obtained from Poynting and Thomson's "Sound," 1899, page 127. As used in the apparatus this distance is 0.226 L from the free end; but laboratory experiments have shown that other values would serve equally

well. The hole should be placed at the point of maximum amplitude.

An opportunity occurred to carry out some further experiments at the Admiralty Experimental Station at Shandon. No long-range work was possible; but work in the Gareloch made it possible, for the first time, to measure the frequency of the note used in the previous long-distance trial. The note was listened to at a distance of 1 nautical mile, and the frequency measured. The average frequency of the dominant note was found to be 880 periods per second, with similar conditions of apparatus and steam pressure as were used in the long-distance trial. There appeared to be two sources of sound, which tend to confuse the listening from the ship (or near to); one from the steam jet, which is dominant, and one from the vibration of the apparatus. By the use of a swinging bar it was found that the former note penetrates, but that the vibration of the apparatus does not carry more than 1 mile. This point was determined by first holding the bar with the hole in the center of the steam, then with approximately half the hole across the steam, and finally with the bar obstructing the steam between the hole and the edge. All three settings gave piercing notes when listened to on deck, but only the first two appeared to reach the listening station, just over one mile away.

The disk was made of mild steel, whereas the bar was of best brass. This latter material, after only 3 hours' running, showed marked signs of pitting, due to the force with which the steam bubbles collapsed; and it is obvious that the obstruction that carries the hole should be of hard material to withstand the wear of constant use. The mild steel disk had been used throughout the sea trials, and showed only the slightest signs of wear.

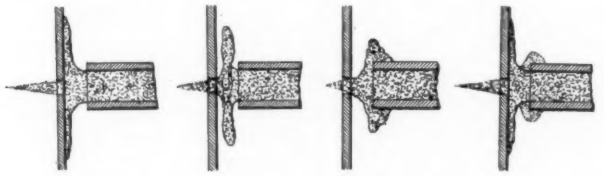


FIG. 3 FIG. 4 FIG. 5 FIG. 6

During the war, the research had been carried on with the object of achieving results; and, beyond noting points as they occurred, nothing was done to investigate the cause of a phenomenon that appeared to be new. The authors have since taken the opportunity of analyzing the production of such a note under water by means of a condensing steam jet, under the auspices of the Manchester Municipal College of Technology.

The work that had already been done pointed so clearly to the production of the note in some way by the action of the condensing steam, rather than by the vibrations of the diaphragm or of the bar, that an attempt was made to ascertain the movements of the jet while a note was being produced. For this purpose a laboratory model was used, which consisted of a straight-through nozzle, ¼ inch in diameter, and a number of mild steel disks 4½ inches in diameter supported in one point only on a nodal circle 0.894 D., by an overhanging adjustable arm. A number of brass bars, 1 inch wide and 5 inches long, were also available. It was with these bars that various positions of the damping node had been tried out. The apparatus was placed in the center of a tank, 26 inches square by 22 inches deep, which could be filled with clear water and emptied at will. The incoming feed-pipe delivered the water near the bottom and an overflow drew it off from the surface. This made it possible for the water to be changed while the apparatus was running, so as to regulate the temperature and counteract the heating effect of the condensed steam. The steam pressure was read on a calibrated Bourdon gage placed just above the tank, the steam supply being adjusted by hand on a stop valve.

Two 3½-inch diameter tubes with watertight glass windows were projected into the tank, one on each side of the nozzle, and a parallel beam of light was passed through. In this way the action of the steam could be watched under water. A stroboscope was used, consisting of a revolving disk with six slots, the width of which could be adjusted, driven by a controllable electric motor whose relative speed was checked by a tacheometer. The arrangement made it possible for the stroboscope to be run at any speed up to 1,200 r.p.m., or 120 periods per second. Various combinations were found possible. A satisfactory result was obtained when a bar was placed ⅛ inch away from the nozzle. With a steam pressure on the gage of 45 pounds per square inch and an average temperature of the water of 63 deg. F., a note was produced whose frequency, compared with a tuning fork in the air, was 420. When the stroboscope was run at a speed of 1,040 r.p.m., corresponding to a frequency of 104, the movements of the condensing steam were clearly visible.

The steam is spread out like a mushroom by the flat surface, while the hotter central core escapes through the hole. The appearance is something like Fig. 3. The mushroom travels backward away from the flat surface in the form of a ring or disk of condensing bubbles. The effect produced may appear like Fig. 4. This ring gradually collapses on and around the end of the nozzle, as in Fig. 5. The onward rush of steam from the nozzle forms another mushroom as the previous one is disappearing, and the process repeats itself (Fig. 6). In both 4 and 5 less steam comes through the hole to the other side of the flat surface. The flat surface acts as a condenser, and possibly as a sounding board, since the thicker it is, the sharper and clearer the note appears to be, within limits. A thin ring of steam nearest to the surface and farthest away from the nozzle condenses first, and allows the water to rush in from all sides. The result is that, momentarily, the flow of steam is checked, and the steam mushroom is forced backward to collapse more gradually against the nozzle. The jet of steam through the hole shortens simultaneously with the retrogression of the mushroom ring. The collapse of this ringed wall automatically relieves the steam pressure, which rushes forward again out of the nozzle, and the cycle recommences. The musical note is apparently produced by a series of pulses or blows rather than by vibration or oscillation. Practically, it amounts to ringing water on water.

It is interesting to note how this theory accounts for the points observed and described in the first part of this paper.

The pitch is known to be higher: (*a*) The smaller the nozzle or (*b*) the lower the pressure, *i.e.*, in both cases, the less the volume of steam flowing per second; (*c*) the farther away the surface is from the nozzle. The less the volume of steam flowing, the smaller and more rapidly formed would be the steam bubbles and the mushroom heads. The periodicity of the note would therefore be higher. The longer the steam jet between the nozzle and the plate, the smaller in diameter it becomes before it impinges round the edge of the hole, and consequently the smaller the mushroom, as before. It is doubtful whether the ring travels back as far as the nozzle when producing these high notes; it probably collapses instead on the jet.

As a check on these conclusions, the stroboscope was removed, and only sufficient steam admitted to form a thin film against the flat surface. No note, of course, was formed, but the repulsion of this film backward could be clearly seen. Osborne Reynolds once explained the singing of a kettle on the hob in a paper read before Section A of the British Association, at Oxford in 1894.[6] He pointed out that at about 10 deg. F. below boiling-point bubbles of steam are formed at the bottom of the kettle, which collapse suddenly with a

[6] Experiments showing the boiling of water in an open tube at ordinary temperatures. Reprinted in *Scientific Papers*, 1901, Vol. II, p. 578 *et seq.*

sharp click when their ascension brings the steam into contact with the colder water above. This is apparently what is happening in the phenomenon just described. The flat surface, be it a diaphragm or a bar, takes the place of the colder water in the kettle, and, being a good conductor of heat and being surrounded by cold water, does not get sufficiently hot to prevent the condensation from being continuous. It may perhaps be noted that if the temperature of the water in the tank is allowed to get hôtter the pitch of the note gradually rises. The effect of the central hole appears to be twofold; it allows the hotter portion of the jet to escape and so facilitates the immediate action of the condenser; and by relieving the pressure it prevents the steam from piling up between the nozzle and the plate and so defeating the mushroom effect.

It will be recalled that the authors found a bar made of best brass to be badly pitted or eroded after only 3 hours running in the sea. This points to comparatively large instantaneous pressures being set up by the collapse of the steam bubbles against the flat surface. In a paper read by the Hon. Sir Charles Parsons and Stanley S. Cook, on "Investigations into the Causes of Corrosion or Erosion of Propellers," before the Institution of Naval Architects on April 10, 1919,[7] a description is given of some water-siren experiments made by A. Q. Carnegie. When the fixed disk was made of soft cast brass, it eroded too badly for use in the siren after 10 minutes' running under a water pressure of 70 pounds per square inch. This effect is attributed to the momentum of each interrupted jet, causing momentarily a vacuous space to form behind it. The return action by concentration finally produces high velocities and pressures in a small volume of the fluid, giving rise—when the nucleus of pressure, or point at which collapse takes place, is located on the metal—to excessive water-hammering over a small area. In Appendix II of the same paper, Cook supposes that a rigid inner boundary to the fluid enclosing a vacuous space is suddenly removed; and he obtains an expression for the instantaneous pressure thus produced. His calculations and conclusions were confirmed by the late Lord Rayleigh in a paper to the Royal Society in August, 1917. Cook shows that the pressure on impact is independent of the size of spherical vortex cavities, and is only a function of the ratio of the initial to the final radii; so that very small cavities may cause erosion. For instance, when a spherical vortex cavity in the sea closes upon a central nucleus of one-tenth of the diameter of the original cavity, the blow upon this nucleus may reach 24.2 tons per square inch. If the diameter of the nucleus is one-hundredth of the diameter of the original cavity, the pressure may reach 765 tons per square inch.

Such instantaneous pressures, if present in the collapsing of steam bubbles against a flat surface, would account for the erosion noted in the brass bar. They would also point to the value of such a means of producing sound under water when long penetration is required, for energy is directly imparted to the surrounding water without the necessity of resonators or of any heavy mechanical apparatus such as is used in present submarine signaling gears.

In conclusion, the authors desire to express their indebtedness to the Admiralty for permission to refer to work which was carried out under their auspices, and also to thank the authorities of the Manchester Municipal College of Technology for enabling them to investigate the cause of what appears to be a new method of producing sounds under water.

RESILIENT STEEL GEARS

A BRITISH company has brought out a type of gears called resilient steel gears which are noiseless and have special features. The teeth of these noiseless resilient gear wheels are built up of a series of steel laminae placd in planes that intersect the axis of the wheel. These laminae are arranged at such an angle to the face of the teeth that they close slightly on one another when the teeth engage; the result is an evenly distributed pressure instead of the hard metallic blow that takes place with solid gears, and even at high speeds and under heavy loads a slight buzzing is all that can be noticed. The laminae are held in position, each independently of the remainder, by clamping plates, annular projections on which fit into corresponding recesses in the lateral extremities of the laminae. In wide wheels one or more center pieces are inserted, and screwed bolts passing through the clamping plates, laminae, and center plates (when employed) fasten the whole together. Between the underside of the laminae and the boss there is a receptacle for lubricant, which is filled in through holes in the clamping plates, and owing to centrifugal force and the slight pumping action, is forced radially outwards between the laminae, furnishing efficient lubrication for the whole width of the teeth.

As compared with raw hide and paper pinions, it is claimed that these gears, owing to the strength and hardness of steel, will carry a greater load, or a given load on a narrower width, and that, being indifferent to wide variations in temperature and impervious to oil, water, or steam, they have a longer life. The resiliency of the working faces of the teeth corrects any small irregularities occurring in these surfaces. A pinion now in course of manufacture for a colliery in the North is intended to transmit 750 horse-power at 295 revolutions per minute. Its width is 13½ inches and its overall diameter 26 inches and there are 24 teeth, 3-inch pitch. The weight is about ¾ ton. The flanges and boss are of cast steel, and the working faces of the teeth of 40-ton forged steel. The gear will hold enough lubricant to last two or three months.

EYESTRAIN IN CINEMAS

AN interim report of the representative joint committee appointed by the Illuminating Engineering Society to inquire into eyestrain in cinemas forms part of the contents of a "special cinema issue" of the *Illuminating Engineer* (32 Victoria Street, S.W.1). The inquiry originated in a request made to the Illuminating Engineering Society by the London County Council for information in regard to the possible causes of eyestrain in cinemas, and the best mode of removing them. Attention was particularly drawn to "the question of the strain to the eyes caused by the proximity of seats to the screen at cinematograph halls, and of some means of lessening the ill-effects referred to." The committee received the coöperation of the Council of British Ophthalmologists and the Physiological Society in dealing with this difficult problem, and seem to have taken great pains to make their investigation as complete as possible. They recommend (1) That the angle of elevation, subtended at the eye of any person seated in the front row, by the length of the vertical line dropped from the center of the top edge of the picture to the horizontal plane passing through the observer's eye, shall not exceed 35°, the height of the eye above the floor-level being assumed to be 3 ft. 6 in.; (2) That provided recommendation No. 1 is complied with, the angle between the vertical plane containing the upper edge of the picture, and the vertical plane containing the observer's eye, and the remote end of the upper edge of the picture should not be less than 25°. They do not anticipate that any supplementary report which they may make will necessitate modification of the above recommendations. The representatives of the cinema industry, while approving of recommendation No. 1, draw attention to the absence of definite evidence of serious injury by eyestrain. In view of this fact, they are of the opinion that where application of this condition to existing halls would entail serious financial hardship there is no justification for its imposition. They are further of opinion that the normal development of the cinema theater will rapidly remove all causes of possible discomfort.—From the *Journal of the Royal Society of Arts*, Sept. 3, 1920.

[7] There is a reprint of this paper in *Engineering*, April 18, 1919, p. 515.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

OUR LEPROSY PROBLEM

THE announcement from Washington by the Surgeon General of the United States Public Health Service to the effect that scientists of the Federal Health Bureau working at the United States Leprosy Investigation Station in Hawaii had discovered in the ethyl esters of Chaulmoogra oil an improved treatment for leprosy is very encouraging, and it is to be hoped that further experience will warrant the optimism with which the new remedy is being received. Chaulmoogra oil, the product obtained by expressing the seeds of an East India plant, has been the mainstay in the medical treatment of leprosy for many years, but unpleasant features associated with its administration have seriously limited its use.

Various chemists have endeavored to secure the active medicinal components free from the constituents that were thought to be responsible for the disagreeable effects, and several of these purer products have been tried by leprologists but scarcely any with the success that appears to have attended the use of the agents employed by the research investigators in Hawaii.

There is an experimental foundation for the use of the derivatives of Chaulmoogra oil in leprosy. The disease is one of a small group due to a member of the "acid-fast" group of micro-organisms. These are germs that have the property of retaining most tenaciously certain dyes with which they may be stained. So strong is the affinity for the dyes in question that treatment with acids fails to discharge the color, hence the term "acid-fast." Recently it has been shown that members of this group of micro-organisms are very sensitive to the action of certain derivatives of Chaulmoogra oil. The members of this special group are killed by the Chaulmoogra oil derivatives in very high dilutions while other groups of organisms require much more concentrated dilutions to be fatally affected. In other words, there is a selective action on the "acid-fasts" by these agents. It is hoped that the same lethal action on the germs in the human body may be brought about. In any event the treatment of leprosy is in a more promising light than it has been before.

The appropriation by Congress of money for a national home for lepers brings the leper problem to us in a more emphatic way than it has been presented heretofore. When we regarded leprosy as a scourge of biblical times or even of the middle ages which remains to this day as an affliction of certain tropical countries or even of our own insular territories, the appeal to our interest was rather remote. But to realize that we have the disease in our own country today and that the prevalence is such as to persuade Congress that the subject must be dealt with by the National Government puts the matter in a different aspect.

The situation is not one that need occasion alarm, but the cold fact is that we have in this country several active centers for the dissemination of leprosy, and the sooner we deal with them in an intelligent fashion the less we will have to fear and to regret. The disease by reason of its very limited contagiousness—it has been shown that but about five per cent of any population is susceptible—should be readily suppressed, but we must not be too sanguine on this score, as experience in many places has shown that the disease is one of the most difficult of eradication that sanitary science is called upon to deal with. The reasons for the lack of immediate success in suppressing leprosy are not entirely clear, but most likely the chief one is the fact that many cases are so slow in development that the victim subjects many healthy persons to contamination before anyone is aware that the disease is present.

One of the most popular misconceptions about leprosy is that it is confined to colored races and that white populations are immune. The truth probably is that all races are about equally susceptible, given the same opportunities of infection.

It is likely in dealing with leprosy that the sanitary authorities will need to consider each case upon its merits. Certain cases of the disease are probably little, or not at all, communicable. Every case must be subjected to searching laboratory study in order that the diagnosis may be made secure and the degree of menace to the community may be estimated.

One of the most curious of the many unusual features of the disease is the fact that it prefers to attack the "male of the species." Wherever leprosy prevails among considerable numbers approximately two male victims to each female are attacked.

The belief, which comes down from biblical times, that leprosy is hereditary has been disproved by modern investigations. It has been shown that when an infant has been removed from a leprous mother immediately after birth the risk that the child will develop the disease is almost *nil*.

We must note that the contagiousness of leprosy varies with the locality. In some portions of the world it exhibits no tendency whatever to spread, while in others it attacks a considerable percentage of the population. The difference in this respect is not solely climatic, nor does it appear to be due to the nature of the surroundings from a sanitary point of view. When we recall that the precise mode of transfer of the disease is not known it is obvious that we must await further developments before we can hope to give a rational explanation for the relative immunity of certain localities.

Leprosy is one of the diseases about which our knowledge is so meager largely because it has not been possible to convey the disease to any of the lower animals in which it might be studied experimentally. Indeed, attempts to transmit the disease to men under artificial conditions have been almost uniformly negative, hence the failure to contaminate animals in which the disease does not occur naturally is readily understood. There occurs among sewer rats a disease strikingly like leprosy in many respects and students of the subject hope that investigation on this analogous disease may lead to useful results which may be applicable to leprosy.

In connection with no disease do we see more unwarranted dread. Indeed public apprehension sometimes reaches the degree of community hysteria, but there is no disease which intelligently handled need cause less apprehension. When the Public Health Service proposed to locate the Government Leprosy Hospital on certain advantageously situated islands off the coast of one of our Southern States, a storm of protest came from the entire Commonwealth; indeed some objections came from adjacent States, and this in spite of the fact that the State in question had a fair number of lepers quite free to come and go as they might see fit.

An organization known as the American Mission to Lepers endeavors to furnish comfort and cheer to lepers wherever they may be found in the United States. It means much to the leper, thrust aside in some isolated corner, to receive a hamper of comforts or a basket of delicacies from the organization, or even better, a friendly visit from the representative of the Mission.

BUBONIC PLAGUE

A MOST encouraging sign of our enlightenment on the subject of pestilential diseases became visible in the past year when bubonic plague appeared at several of our seaports on the Gulf of Mexico. There was no great alarm felt; no quarantine was imposed and no ill-judged methods of eradication such as the burning of infested quarters of cities, which once was regarded as a desirable method of fighting plague, were employed. Doubtless the confidence which the public has in its sanitary officers to control epidemics accounted for the relative indifference with which the announcement of the presence of plague was received.

As a matter of fact those who have given the subject of bubonic plague much consideration feel that the disease can never become a very serious menace in this country.

Our first acquaintance with plague on the mainland of the United States, and indeed of the western hemisphere, occurred about 20 years ago when the disease was introduced from the Orient and effected a lodgment on our Pacific Coast, from which in fact it has never been entirely dislodged though held in such check as to be well-nigh negligible as a menace to life.

Even earlier than this our Pacific insular possessions had become acquainted with the disease which, judged by oriental experience, we had every reason to fear would prove a tragic addition to the lists of communicable diseases with which we would be called on to deal.

The history of plague may be traced in both sacred and profane history of thousands of years ago and it is an interesting fact that in spite of what may be regarded as clear enough indications in these ancient writings of the relation, so well understood now, which the disease bears to rats, the proof of this relationship had to wait until a few years ago, and then it became the basis of our methods of fighting plague.

Bubonic plague may be regarded for all practical purposes as a disease of rodents, chiefly rats, that occasionally attacks man.

As already mentioned it had been noted in very early times that a pestilence prevailed among rodents coincident with plague in man, but the relation between the two was not understood until experiments conducted in India showed that the disease was carried from sick rats to man through the agency of fleas. As it is easier to destroy rats on a large scale than to destroy fleas the former are regarded as the weakest link in the chain of transference of the disease, and efforts are directed against them and with great success.

In a plague outbreak, so far as suppression goes, human cases may be ignored for all practical purposes, for the type of the disease we are considering never spreads directly from one person to another, but is always carried from a rat to a man. Therefore our efforts should be directed to the root of the evil.

Rats are very cunning animals and their utter extermination is not even to be hoped for, but they can be diminished in number to a very great extent, so great as to meet the requirements for plague control. The means of killing rats are traps and poisons. In addition much can be done to starve out the animals. The latter is best accomplished by legal requirements to the effect that anything which serves as rat food shall be made unavailable to rats. Perhaps the best way to cut off the rats' food is to dispose properly of garbage. In an anti-rat campaign the lowly garbage can plays a mighty part. The trapping and poisoning cannot be left to the individual citizen but must be carried on by men under the control of the sanitary organizations.

The trapping serves two purposes: It reduces the number of rats, and it secures rats for the laboratory studies which are necessary to determine the extent and severity of the infection among the rodent population—a very important matter, as intelligent direction of the campaign depends on this.

Plague is one of the many diseases that follow trade routes and shows a tendency to be confined to the more important trade channels. This of course is the result of its peculiar mode of transfer, as the chances of contaminated rats following direct and important trade channels rather than less important ones is obvious. In times past, and indeed to some extent at present, the commercial loss occasioned by quarantines imposed with the object of restricting the spread of plague has been very extensive. Since it has become generally accepted that rats alone need to be considered and as we have very effective means of dealing with rats on vessels, obstructions to commercial intercourse by quarantine has been very much reduced. Vessels can be fumigated at our quarantine stations with sulfur gas or, as has become very popular in later years, with hydrocyanic (prussic) acid gas, so thoroughly as practically to eliminate the danger of any rats surviving and spreading the disease. When ships are allowed to dock at a plague-infected port or when they arrive at a clean port from a plague-infected one, elaborate precautions are taken to prevent rats possibly infected from passing from vessel to shore or vice versa. Metal rat guards are applied to all hawsers, loading is permitted only in daylight hours, gangways must be raised at night, and the vessel must be kept from close proximity to the dock by fenders.

There is another form of plague known as the pneumonic type, which is not so thoroughly understood as is the one referred to thus far. Fortunately we have little to fear from this form, as it has shown no tendency to spread in the United States, though our experience has been confined to one small outbreak.

The pneumonic form we know best by reason of its ravages in North China some years ago. As the name signifies it is a disease which affects primarily the lungs. Thus far the great epidemics in modern times of this form of plague have occurred in cold climates. The information we have indicates that pneumonic plague is transmitted directly from person to person, and that it does not involve any of the lower animals. This form of plague is almost always fatal.

Efforts have been made to fight plague by means of a vaccine and the results are encouraging but cannot at present be regarded as sufficiently promising to take the place of anti-rodent operations. Very encouraging results, however, have been reported from the use of a serum in the treatment of the disease.

Plague is a good example of those diseases our knowledge of which has been extended by experiments on animals. Animal inoculations have given us proof of the mode of transmission of the disease, and on this is based all of our procedures for controlling it.

Animals are also used in establishing the diagnosis of the disease in man and in rats, both matters of great importance in the inauguration and continuation of control measures.

SUBSTITUTES FOR PLATINUM

AN alloy of nickel and iron known as "Platinite" is being used in place of platinum in incandescent lamps. Nickel-chromium is sufficiently resistant to chemical action to render it a fairly good substitute for platinum in the laboratory. Cobalt is even better than nickel when in contact with strong acids. The melting point of gold may be raised by alloying it with palladium producing an alloy known as "Palau." Bureau of Standards tests show this to be superior to platinum in some respects and inferior in others.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

INCREASING THE PROTEIN CONTENT OF WHEAT

PROFESSOR W. F. GERICKE of the University of California presents, in *Science* for November 5th, the results of investigations on methods of increasing the protein content of wheat

Wheats of the Pacific Coast States are conspicuously low in protein, so much so that western millers are obliged to ship in large quantities of high protein wheat to mix with their domestic wheats in order to manufacture flour of good baking qualities. The cause of the low protein content of western wheats has been the object of considerable investigation on the part of interested agronomists and plant physiologists for the last two decades. Results obtained from these investigations have led to a rather common belief that the cause of the low protein content of Pacific coast wheat is primarily attributable to peculiar influences of climate.

Professor Gericke's investigations show that this belief is not correct, but that the protein yield is correlated with the application of certain forms of soluble nitrogen at different growth periods.

The data collected show a decided increase (about 77 per cent) in the protein content of wheat obtained from the plants that received nitrogen when they were 110 days old over those that were treated with nitrate at the time of planting. The protein content of the wheat obtained from these two different treatments are respectively 15.2 per cent and 8.6 per cent. The data show that for each of the different applications of nitrate made after the time of planting, there was a corresponding increase in the protein content of wheat. As these increases in the protein content of wheat correspond with the length of the period of the different deferred applications of nitrate made after planting, this would indicate a significant relation between the state of development of the plant and the time when nitrate can be most effectively utilized by the plant in the production of high protein wheat. This emphasizes that the physiological status of the plant, as indicated in its different growth phases, is a factor of great importance in the utilization of plant food available to it.

Not only was the protein content of the wheat increased by all of the deferred applications of nitrogen, but the yield of produce, excepting that obtained by the latest application, was much larger from the plants that received nitrogen for the period of 33 to 72 days after planting than those that received nitrogen during the early growing period. The best quality wheat as determined by commercial grading was secured from the plants that received nitrogen 72 and 110 days after planting. This means that the high protein wheat berry was likewise plump and well filled.

Professor Gericke concludes that the results obtained in this investigation show that the low protein content of Pacific Coast States wheats is not due primarily to the climate as such, but to insufficiency of available nitrogen at certain growth periods of the plants. That climate is not without effect upon the availability of the plant food in the soil is obvious, but the emphasis to be laid on the climatic complex is that it affects the nutrition of the plant. This can be both in the kind and quantity of each of the different nutrients that may be available to it. That this availability is an important factor in affecting the composition of plant products is shown by the results of this investigation.

DESERT VEGETATION AND BORON

IN the Journal of the Washington Academy of Sciences for October, 1920, Mr. Karl F. Kellerman of the Bureau of Plant Industry presents an article on the effect of salts of boron upon the distribution of desert vegetation.

The disastrous experience of the past two seasons in the use of fertilizers contaminated with varying percentages of borax has sharply drawn attention, Mr. Kellerman says, to the importance of considering boron compounds not only in fertilizer investigations but also in investigations of alkali deposits wherever agricultural developments are to be considered. While geologists are familiar with commercial developments of borax, it has not been generally appreciated by botanists or others interested in the vegetation of the desert regions that extensive deposits of borax are recorded in many localities in the western United States.

It is perhaps a question whether the desolate character of some of the western and southwestern deserts can be directly correlated with the occurrence of borax in quantity within these areas. Apparently no such correlation has been suggested, either by geologists or by engineers or agriculturists interested in reclamation and irrigation problems in these regions. The Smoke Creek Desert, the Carson Desert, Death Valley, and the Mojave Desert are remarkable for their barrenness; and in view of the occurrence of borax in these regions, it would seem to be a fair suggestion as to whether the contamination of borax in the soil might not be responsible to as great a degree as the low rainfall, for the absence of vegetation. Furthermore, those familiar with the topography of these deserts will recall the peculiar absence of vegetation from mud flats even when these are gradually drying out; they occasionally dry into perfectly level plains, hard and smooth, apparently not badly troubled with alkali but with no sign of vegetation.

In view of the records of the rather wide distribution of borax, it seems not unreasonable, therefore, to suggest that the irregular and rather definitely located occurrence of borax may explain the injury to plants on these small areas. Mr. Kellerman in his investigations personally collected small samples in the alkali spots in Kern County, Cal., where plants were either dying or completely absent. Borax percentages of significant size were found in these samples, although, with the rather high content of the white alkali salts in these spots, it was difficult to determine the relative importance of borax and the other salts in the alkali injury.

Plant physiologists have frequently included boron compounds in determining the toxicity of various compounds upon plants, both in water cultures and in sand and in soil, but there are nevertheless differences of opinion regarding the toxic action both of borax and other boron compounds. One of the conclusions is that boric acid seems to be less harmful to the higher plants than compounds of copper, zinc, and arsenic; and, further, that below a certain amount of concentration boron compounds exert a favorable influence upon plant growth.

Mr. Kellerman as a result of his investigations doubts the validity of this opinion, and considers the stimulating effect to be due to a suppression of the growth of competing organisms such as bacteria and molds on the control plants of water cultures and the bacteria and protozoa in the sand and soil cultures. It may also be doubted, he says, whether the conclusion regarding the relative toxicity of boron compounds and compounds of zinc and copper is valid. If one is considering plants growing in natural soil, zinc and copper compounds are certain to become transformed into insoluble compounds much more rapidly and completely than is the case with boron form deposits that represent natural accumulations. Therefore, it may not unfairly be presumed, he thinks, that boron will prove to be a more toxic element than either zinc or copper.

The toxicity of boron compounds to different crops under field conditions has not, Mr. Kellerman concludes, been adequately investigated. His opinion is that it will almost certainly be found that different crops will show a great range in their resistance to borax poisoning, and it is probable that there may be found to be some direct correlation between the action of the plant in absorbing boron compounds and the limit of the toxic concentrations.

Finally, he says, that much additional investigation, both in the field and laboratory, is necessary before it will be possible to determine the significance of borax either in its relation to natural vegetation or its bearing upon agricultural development in irrigation projects or in the use of fertilizers.

THE EFFECT OF LIGHT EXPOSURE ON PLANT GROWTH

THE *Botanical Gazette* for September, 1920, directs attention to the work of Messrs. W. W. Garner and H. A. Allard in determining the effect of light exposure on plant growth. These investigators have grown plants under different conditions of light exposure, and have made a special study of the tendency to become reproductive or to remain vegetative under varying daily lengths and intensities of exposure. Several varieties of tobacco and soy bean were mainly used in the experimental work, although numerous other species of annuals and biennials were used to check the results attained.

Plants were grown in pots, buckets or boxes, and at the desired time each day were moved into dark chambers which were placed in the field. Time of exposure to light varied in the different tests from 5 hours daily to full daylight, 7 and 12 hours being the exposures chiefly used. Checks received full daylight under similar conditions of temperature. Shorter light exposures were all made during the middle of the day, and during the time of highest light intensity, except one series of soy beans which were kept in darkness from 10 A. M. to 2 P. M. daily.

In general, the amount of vegetative growth was proportional to the length of daily exposure to light. The short exposures resulted in short, slender plants of greatly reduced size. Rate of growth was much slower, and the total size attained was reduced. The inception of the flowering or reproductive phase was greatly influenced by length of exposure to light. Many of the species worked with were thrown into flowering and fruiting by the shorter exposures, while with certain other species and varieties, reducing the period of illumination had little effect upon the inception of fruiting.

The authors conclude that for each plant there is a "critical" length of daylight exposure essential to the development of the fruiting phase. The length of this critical exposure varies with each species and variety, but, in many individuals at least, is very much shorter than normal summer daylight. By exposing the plants to this critical length of illumination, the reproductive or flowering phase can be induced at almost any time. By varying this time of exposure, typical biennials, as *Aster linariifolius*, could be made to complete their life cycles within a few months, while annuals, as soy beans, *Solidago*, etc., could be induced to respond as biennials.

Experiments with shading indicated that time of exposure, and not light intensity, is the primary factor involved in determining the critical day. Light intensity reduced to 43 per cent by shading had no effect upon the time of inception of fruiting, although it did give typical shading results on form and amount of growth. Of significance, however, is the result obtained from exposing soy bean morning and afternoon, but keeping it in darkness during midday. Time of fruiting was not materially altered by this treatment, although it was much advanced in the same variety by reducing the exposure to light through leaving in darkness morning and evening. Reducing the water supply reduced vegetative growth and fruit yield, but did not alter time of fruiting in the least. Winter light, supplemented by artificial illumination at night, giving a total daily exposure of 18 hours, acted exactly as long summer daylight in its tendency to retard or prevent fruiting. The authors believe length of day, through its influence on fruiting and seed formation, to be a fundamental factor in plant distribution.

HYBRIDIZATION AND EVOLUTION

IN the *American Naturalist* for June, 1920, Professor E. M. East, in an article entitled "Hybridization and Evolution," gives an account of results obtained in the crossing of two species—*Nicotiana rustica* L. and *Nicotiana paniculata* L.

The cross between these two species gives an F_1 generation intermediate between the two parents, and as uniform in each character as either parental group.

Few of the male or the female gametes are viable, yet by careful attention to pollination, from one to twenty seeds can be obtained in the capsules, where normally two hundred to three hundred seeds are found. These seeds produce an F_2 generation which is inordinately variable. No two plants are similar, and numerous types can be picked out which if found in the wild would undoubtedly be classed as different species. In genetic terms, the behavior of the two species may be described as follows: They differ in an extremely large number of inherited factors; and owing to these numerous differences, many of the otherwise possible combinations of F_1 gametes, are not functional. A huge percentage of expected combinations of both gametes and zygotes are thus eliminated.

The factors which in combination produce normal fertility, recombine in the Mendelian sense, quite as do the factors controlling the form of leaf and flower. The result is that after a few generations of selection one may obtain a variety of strains, uniform within each line, so fertile as to yield capsules with over ninety per cent of the normal quota of seed, and so different from one another that the extreme types are more unlike than the two original species used in the cross.

After three years of selection (F_5), eight such strains remained out of a large series of selections studied earlier. The smallest type was about 20 cm. in height with small smooth oval leaves, and the largest was nearly 200 cm. in height with wrinkled cordate leaves some of which were 50 cm. in length. *These eight strains were crossed in all possible combinations, and every F_1 generation exhibited as high a degree of fertility as that shown by the parents.*

These results are regarded by the author as having an important bearing on certain important problems concerning evolution. The enormous variability of the F_2 generations arising from partially sterile F_1 generations produced by crossing species, lead one, he thinks, to suspect that such combinations might be the basis of a great deal of variability responsible for evolution under domestication. A careful survey of the evidence relating to the origin of modern horses, cattle, sheep, swine, dogs, guinea pigs, fowls, ducks and geese on the one hand, and varieties of wheat, corn, barley, oats, rye, apples, grapes, roses and begonias on the other hand, shows that in every case several related wild or semi-wild species exist which will cross together and yield partially fertile offspring. Both the historical and the experimental evidence, therefore, point to hybridization, and particularly to species of hybridization, as the great single cause of evolution under domestication.

At the same time, however, the author says, one must not confuse evolution under domestication with natural evolution. The outstanding biological feature characteristic of the varied groups of domestic animals and of cultivated plants, is the perfect fertility within each group. A marked peculiarity of the great majority of natural species is their sterility with one another, the origin of which has long been a stumbling block to writers on evolutionary biology. His own experimental evidence, as far as it goes, and observations on domestic forms which presumably have originated from combinations of two or more wild species, yield, he thinks, not the slightest indication of a tendency toward the production of segregates that exhibit either incompatibility in crosses or sterility of the individuals produced by hybridization.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

INVESTIGATION OF DENTAL AMALGAMS

It is not generally understood how far-reaching the effects of certain scientific investigations may be. To the average person, it seems a far cry from the accurate measurements of length to the development of an improved dental amalgam, yet this is just what has occurred in connection with some of the recent work of the Bureau. A large percentage of all dental work is in connection with amalgam fillings. Early in the war the Surgeon General's Office of the Army was in the market for a very large amount of this material and it seemed highly desirable to determine the ingredients which would make up the best quality of amalgam filling. The War Department, therefore, requested the Bureau of Standards to investigate the subject, and, if possible, develop a specification which could be used to govern the purchase of this class of material.

As soon as the study of the subject was commenced, it was evident that almost every manufacturer of a dental amalgam had a different idea as to what its composition should be. The Bureau, however, believed that as in every other case, there must be some one composition which would best meet the requirements, and that the use of so many different kinds simply indicated that the subject had not received thorough scientific attention. An important requisite in connection with any material used for filling teeth is that the filling shall remain tight over as long a period as possible. Leaks between the filling material and the tooth quickly result in decay. From previous experience, the Bureau had learned that a common cause of loose joints between two dissimilar materials is due to differences in the coefficients of expansion of the two substances. It was, therefore, deemed advisable to determine with the highest possible accuracy the coefficient of expansion of the tooth substance and the various classes of dental amalgams. When this was done, it was found to the surprise of many of those interested, that a large number of the amalgams had coefficients of expansion differing very widely from that of the tooth substance. This means that upon any change in temperature the tooth and amalgam will expand by different amounts and this can, of course, have but one result, a loose joint between the tooth and filling. After a large amount of experimental work, an amalgam was developed, the coefficient of expansion of which was practically the same as the tooth substance. The results of this work were embodied in a formula which became a part of the specifications of the War Department for this material.

During the work, the opinions of many of the leading dentists of the country were secured as to what qualifications should be possessed by good amalgams, and the consensus of opinion thus secured was embodied in the specifications. Recently a lecture on amalgam fillings was prepared by a member of the Bureau's staff and presented before the Dental Society of the District of Columbia. It was gratifying to note that the Society expressed great appreciation of the work which has been done along this line by the Bureau.

DIFFICULTY IN CONNECTION WITH SMALL LENGTH MEASUREMENTS

Certain difficulties arise in connection with the precision measurement of small lengfhs which make necessary the use of special apparatus for such work. It was mentioned in the notes for last month that a part of the work of the length section of the Division of Weights and Measures is in connection with the determination of the accuracy of fine wire sieves such as are used in the testing of cement. Besides knowing accurately the number of wires per inch in such sieves, it is also necessary to know as closely as possible the diameter of wires. As these are extremely small, the accurate measurement of their diameter presents some difficulty.

A method used for determining this has been to make the measurement with a micrometer microscope having two parallel cross hairs a short distance apart. The microscope is adjusted so that these two cross hairs are parallel to the edge of the wire, the latter coming midway between the two cross hairs. A reading is taken at this position of the microscope. The instrument is then moved so that the cross hairs come upon opposite sides of the other edge of the wire; the difference between the two readings thus obtained gives the diameter of the wire.

Recently an investigation was conducted to determine whether a personal error existed in making readings of this kind. As the result of many observations carried out with the same microscope and wire by different observers, it was very evident that such an error did exist. In other words, no two observers adjust the microscope to exactly the same position to obtain what they consider to be the central position for the edge of the wire between the parallel cross hairs. This error is undoubtedly due to the difficulty in matching a dark and light space represented in the above case by the wire itself and by the vacant space beyond the wire.

The Bureau believes that a more satisfactory way of measuring these small diameters may be secured by the use of a projection apparatus which will throw a shadow of the wire upon a screen a fixed distance away. By obtaining the size on the screen of a wire of accurately known diameter, it is possible to calculate very easily the diameter of any other wire placed in the projection apparatus.

COMPOSITION OF SLUSHING OILS FOR RUST PREVENTION

Technologic Paper No. 176 of the Bureau of Standards contains a detailed discussion of the above subject, an abstract of this paper being as follows:

Slushing oils are materials used for protecting bright metal where it is not practical to use paint, varnish, or other fixed coatings. An ideal slushing oil is one which can be easily applied to all kinds of metal surfaces by a variety of methods. It should coat the surfaces with a sufficiently thick and impervious film to exclude moisture and air (to prevent rusting), should remain in position for an indefinite length of time, and yet be completely removable from the surface without undue labor. The material should itself have no corrosive action on any kind of metal.

This paper contains a discussion of properties and methods of testing, most of which were developed in the course of this investigation, and summarizes results of tests of a number of samples. From a study of numerous laboratory and exposure tests proposed specifications are given. The specifications suggested are based upon properties of the finished product rather than chemical composition. Formulas are given of some satisfactory mixtures, but it is not claimed that these are the best slushing oils that can be made. They are merely cited as examples of easily made preparations which were found to protect metal.

SPECIFICATIONS FOR RUBBER JAR RINGS

The preserving of fruits and vegetables in the home has always been a matter of considerable importance and particularly so during recent years with the prevalence of high

prices for such articles when bought at the retail stores. One essential for successful work of this kind is that the jar in which the food is placed shall be absolutely airtight. Most of the jars used for this work consist of a glass body and cover sealed by a wire device and a rubber ring. These rings should be made of good quality of material with as long life as possible. In order to develop a satisfactory specification for these rings, the States Relations Service of the Department of Agriculture asked the Bureau to investigate the subject and to report upon the most satisfactory material to use for this purpose. The specifications prepared as a result of this work have proved very satisfactory. The States Relations Service has recently asked the Bureau to make another investigation of the subject in order to still further improve the quality of the product. Many manufacturers are already producing jar rings of a high quality but the Government desires to prevent entirely the manufacture and sale of inferior rings.

LIME, ITS PROPERTIES AND USES

A SECOND edition of Bureau of Standards Circular No. 30 with the above title has recently appeared. The object of the circular is to give general information as to what lime is, how it is made, and what it is used for. As the importance of information on this subject can be readily understood, it is believed that an abstract of the paper will be of interest.

Lime is made by heating limestone under certain conditions whereby it is decomposed into an escaping gas, carbon dioxide, and a non-volatile residue, lime or quicklime. This lime, when treated with water, hydrates or slakes if water is used in great excess, and a paste results, but if the amount is properly regulated, the hydration yields a dry powder which is called hydrated lime.

Since natural limestones contain more or less magnesia, iron, silica, etc., the quality of the lime will depend to some extent upon the nature and amount of these foreign materials. It will also depend upon the way the stone is burned.

As a material for building construction, hydrated lime is better adapted than quicklime because it eliminates the labor usually required to do the slaking. It is used very largely as a brick mortar, as an ingredient in concrete, and in the scratch and brown coats of plaster. A particular grade of hydrated lime, noted for its plasticity, is sold as finishing lime and is used for the white coat of plaster.

Limestone, quicklime, and hydrated lime are used to a large extent as chemical reagents in the manufacture of other materials. In some of these industries the quality of the lime is of minor importance. In others, the use of only one of the three forms of lime is satisfactory, and the quantity and kind of impurity which the lime may contain is definitely specified.

Eighteen of the most important chemical industries that use lime are enumerated. Brief descriptions of these industries are given, showing why and how they use lime, and the quality of lime which they require.

A list of the tests of lime which are usually made includes chemical analysis, rate of hydration, plasticity, sand carrying capacity, time of set, compressive strength, proportion of waste, and fineness.

ARTIFICIAL SEASONING OF GAGE STEELS

FOR use in checking up the gages used in manufacturing plants, steel blocks are employed which are commonly known as gage blocks. These have two surfaces an exactly known distance apart, the surfaces likewise being plane and parallel to one another. An important qualification of these blocks is that they shall not be subject to dimensional cnanges over long periods of time. This makes necessary the use of certain special steel alloys and of special seasoning processes. Recently an investigation has been carried out to determine the effects of various artificial seasoning treatments on the permanence of gage steel and this has already progressed sufficiently far to permit of certain conclusions being drawn.

In this work hardened gages were heated in oil at various temperatures and under varying conditions, and also subjected to seasoning by alternate dipping in hot oil and iced brine. The results are as follows:

(1) Short gages (1/8 inch) showed no appreciable changes in length, with or without various artificial seasoning treatments, over a period of approximately 7 months beginning about 1 to 2 weeks after hardening. In general the long gages (2 inch) showed no appreciable changes in planeness.

(2) For studying length changes with time, gage blocks of greater length than those used (2 inches) would be desirable. About 6 to 8 inches is recommended.

(3) Duplicate gages show wide variations in length changes, for example, one block showed no dimensional change in 217 days between the first and last measurements while a duplicate decreased eighteen hundred thousandths of an inch in length in the same period.

(4) Except in the case of plain carbon steel containing 1.18 per cent carbon the changes in planeness are not appreciable. In this steel relatively large variations in planeness for duplicate gages are noted.

(5) Gages produced from stainless steel and ordinary drill rod are softer than reference blocks ordinarily produced and which are kept between about 90 to 100 Shore hardness. From this standpoint, the stainless steel is unsatisfactory as it is not possible with ordinary treatment to maintain the hardness within the limits described. A higher-carbon alloy of this type would be more desirable, with possibly a decrease in chromium such as would not impair its stainless qualities and at the same time reduce production costs.

(6) The plain-carbon steel (containing 1.18 per cent carbon) appears to be the least desirable from the standpoint of permanence, showing in the main the greatest changes in length and planeness during a period approximately 7 months from first to last measurements. Probably the most desirable are steels HC and K subjected to definite seasoning treatments, the former being the steel now generally used in production of reference gages at the Bureau of Standards.

(7) Measurements at intervals of approximately one week, two, four, and seven months after initial readings of length and planeness do not give very much information regarding the progress of the changes taking place. Where the greatest changes occur in either length or planeness they appear to increase progressively with time. In many cases where these changes have been smallest over the entire time interval they seem to occur in the intervals immediately following the first measurement, the gages thereafter remaining constant.

THE STANDARD SAMPLES DISTRIBUTED BY THE BUREAU

ONE of the important functions of the division of Chemistry is the distribution of standard samples of material. These are prepared with great care and before a sample is issued it is analyzed by a number of different laboratories, the results being carefully checked with the values obtained at the Bureau. The demand for these samples is quite large and during the past month 33 new customers were added to the list. During November 434 standard samples were issued on 128 orders; two of the samples being new ones, Nos. 23-a and 51, and consisting of Bessemer 0.8 per cent carbon steel and Electric furnace 1.2 per cent carbon steel, respectively.

A TABLE OF CERTAIN WEIGHTS AND MEASURES

THERE has recently been prepared for distribution a table of equivalents of United States gallons in terms of British Imperial gallons and vice versa, from 1 to 100. The tables also aply to other units of the same relative sizes, such as, for example, U. S. quarts to British Imperial quarts. Another paper containing information on the weight per cubic foot of broken limestone and its dependence upon the specific gravity of the solid material and the percentage of voids has likewise been prepared. The voidage of certain other loose materials, such as sand, gravel, and stone, is also given.

Research Work of the U. S. Bureau of Forestry

Notes from the Forest Products Laboratory at Madison, Wisconsin

RESEARCH IN WOOD AT THE FOREST PRODUCTS LABORATORY

THE cutting of timber and manufacture of wood products is the second largest industry in the country and it is also the most widespread. Prior to 1910 research in wood had been conducted in a disconnected way but the total volume of work was small as compared to many minor industries. Very little scientific research work in wood had been done, methods of utilization being based largely on tradition and the customs of the centuries.

The Forest Products Laboratory was established in 1910 by the United States Forest Service in coöperation with the University of Wisconsin in buildings on the campus at Madison, Wisconsin. The work of the laboratory is confined entirely to wood. In this work about 200 scientists, engineers and skilled artisans are employed grouped in the following sections: timber mechanics, timber physics, preservation, derived chemical products, pathology, and industrial investigations.

The great advantage of this laboratory is that all necessary facilities are assembled in one place to undertake any type of work on the single material—wood.

Notes from time to time on the work of this laboratory will appear in these columns. These notes will discuss interesting developments as they take place.

CONVERSION OF SAWDUST INTO CATTLE FOOD

MAKING the sugar contained in wood available as an easily-digested food has been one of the chemical research problems of the Forest Products Laboratory. Preliminary feeding trials of a product developed has been completed and additional extended trials will be conducted this winter by the University of Wisconsin.

The process of preparing a wholesome cattle food from coniferous wood depends upon the conversion of part of the wood into sugar by cooking it for about fifteen minutes with a dilute acid under 120 pounds steam pressure. In this treatment about 20 per cent of the wood is converted into sugar and the remainder rendered more digestible. The sugars are then extracted from the digested dust with hot water, the acid removed from the resulting solution by neutralization, and the liquor evaporated under reduced pressure to a thick syrup. The concentrated sugar solution thus obtained is then remixed with the residue left after cooking and the whole dried to less than fifteen per cent moisture content. The finished material is darker than the original sawdust, is very brittle, and contains a larger proportion of fine dust.

A preliminary feeding trial, using a product prepared in this way from eastern white pine, was conducted by the Wisconsin College of Agriculture with favorable results. Three cows were fed by the reversal method for three periods of four weeks each. In the first and third periods they were given an excellent ration, consisting of alfalfa hay, corn silage, and a concentrate mixture of fifty-five parts of ground barley, thirty parts of wheat bran and fifteen parts of linseed meal. In the second period hydrolyzed sawdust was substituted for part of the barley, two pounds of sawdust being fed in place of each pound of barley, as it was not expected that hydrolyzed sawdust would have as high a feeding value, pound for pound, as barley. The mixture used during the second period contained about 26 per cent of hydrolyzed sawdust. At no time was any difficulty experienced in getting the cows to clean up this concentrate mixture. The cows maintained their production of milk as well in the second period as in the first and third and showed an appreciable increase in butter fat production. A decided increase in weight was noted during the period in which they were fed the treated sawdust.

While no definite conclusions can be reached from this brief trial, these results do show that cattle may be fed a limited amount of hydrolyzed sawdust and that in this trial the feeding value as a source of carbohydrates or energy was half that of barley. It should be pointed out that hydrolyzed sawdust contains only a negligible amount of protein and in this respect cannot be compared with barley. In both rations used in this trial plenty of protein was furnished by the other feeds used.

CRATING AUTOMOBILES FOR EXPORT

A PRELIMINARY study by a packing engineer of the Forest Products Laboratory at eleven automobile and truck plants in the Detroit district indicates that great improvements can be made in the method of crating used by the American car manufacturers. It is probable that in the pressure of getting a large production to make the deliveries that the automobile business of the last few years has demanded, the important matter of safe packing has been overlooked. People were so glad to get a car that they were not greatly interested in the condition in which it arrived. Long strings of gondola cars with automobiles on them unprotected from the hazards of transportation, except for a tarpaulin, have been a familiar sight in the automobile district. But now conditions have changed and better packing is receiving the attention of manufacturers and exporters.

Many defects of good packing and crating were noted in this study. There seems to be a very general practice of end grain nailing of frames. No cases were found where three-way corner construction was used. No use is made of bolts except to fasten parts of the car to the frame.

Manufacturers are about evenly divided between southern yellow pine, Norway spruce and spruce for crating work. One company favored spruce as not so easily split as pine.

The reported cost of boxes varied from \$50 for a small automobile to \$170 for a 5-ton truck.

The outstanding feature of the study was that at the present time there is no uniform standard practice in boxing automobiles and trucks for export. Research work that it is hoped will lead to standardization has been undertaken at the Laboratory. In view of the probable growth of the export trade in automobiles it is especially important that some uniformity in packing methods be developed at an early date.

PULPING PROPERTIES OF AMERICAN WOODS

THE Forest Products Laboratory has carried on an extended investigation over a period of more than ten years and has collected experimental pulping data on practically all the possible species of American pulp woods. These data, in so far as the chemical pulps are concerned, have mainly been obtained from experimental cooks in 100-pound semi-commercial digesters installed at the Laboratory and from studies made on the resulting pulps. It has been found, however, that the general cooking conditions, yield, bleach, consumption, etc., as determined by experimental trials for pulp made from any given wood, compare favorably with the results obtained in commercial practice. The data for the various mechanical pulps were obtained from experiments carried on at the ground-wood laboratory, Wausau, Wisconsin, where a commercial-sized grinder equipment was installed by the Forest Products Laboratory in coöperation with the American Paper and Pulp Association.

The yield of pulp from any given wood depends directly upon the specific gravity of the wood or weight per cubic foot and the pulping method employed. By varying the severity of the pulping treatment both yield and bleach consumption are changed. For example, white spruce sulphite pulp prepared for the manufacture of newsprint paper, would show an entirely different yield and bleach consumption from bleached white spruce pulp prepared for use in a white bond paper. It is, therefore, evident that the character and use of the pulp will largely decide the severity of the cooking operation. Certain woods, such as western larch, containing a high percentage of galactan, which is water-soluble, will show a decreased yield by either mechanical or chemical pulping.

Pulping data are available for woods such as red and white oak and white ash not generally considered suitable for pulp purposes. Many wood-using plants produce considerable tonnage of slabs and mill waste of woods not especially suitable for pulp production, and are interested in a possible outlet for this waste. In some cases, at their direct request, pulping trials have been made on woods known to be unsuitable for pulping purposes.

Information on the pulping qualities of 61 woods, including resinous, non-resinous, and hardwoods, is available at the Forest Products Laboratory. This information includes data as to the weight per cubic foot, fibre length, yield of pulp per hundred cubic feet of wood, bleaching properties for some pulps, range of growth of woods, and common names in diffenent localities.

RELATION OF MOISTURE TO THE PROPERTIES OF WOOD

THAT moisture affects the properties of wood in many ways has been known from time immemorial, and the shrinkage and swelling of wood produced by changes in its moisture content has always been and still is the bane of the manufacturer. The proper control of the moisture factor forms the greatest problem of the wood user. Green wood is of little use for most purposes, and the extraction of the moisture through seasoning or kiln drying without injury such as checking, honey-combing, warping or introduction of internal stresses is an art requiring the highest degree of technical knowledge and skill. That the moisture factor is of basic significance in the use of wood was rudely and abruptly forced upon the attention of this country at the beginning of the war, as it was absolutely impossible to build serviceable guns, aeroplanes, army wagons or artillery wheels without properly dried wood. None was available. The Government turned to the Forest Service for help, where this subject had been studied continuously for the past fourteen years. A method of successfully seasoning the green lumber without injury to its strength had already been developed and used commercially and this was immediately put into application on a large scale, for the drying of the wood for all kinds of war purposes. Moreover, a special dry kiln in which the process could be successfully applied had previously been designed and operated commercially. Over three hundred of these Forest Service water spray kilns were established and the wood dried in time for the emergency.

The Forest Products Laboratory has been studying the problems arising from the effect of moisture upon wood continuously ever since its establishment, ten years ago, and previously to this the relation of moisture to strength and of methods of drying to strength had been studied for seven years by the Forest Service in its former laboratories. The subject is so complex in its nature, however, that there yet remains an immense field unexplored. Especially true is this of the shrinkage relationships and internal stresses. The behavior of a piece of wood during the removal or absorption of moisture or water is not a simple matter but depends upon the interaction of many separate factors whose inter-relation is largely unknown or indeterminable. An idea of the complexity of the problems may be obtained from the following premises:

1. Moisture is contained in wood in two conditions; as free water occupying the interstices in the cells, and as hygroscopic moisture contained intimately associated with the wood substance itself. The wood substance becomes completely saturated with hygroscopic moisture with from 25 to 30 per cent of its dry weight and will then take on no more moisture. However, free water may still enter into the wood to the extent of 100 to 200 or even more per cent of the dry weight.

2. Removal of the hygroscopic moisture alone causes dimensional and physical changes, but under certain conditions the removal of the free water may cause the cells themselves to collapse.

3. Wood becomes soft and somewhat plastic when hot and moist, and hardens or takes a "set" in whatever shape it dries. If it dries under tensile stress it becomes set in an expanded condition and, if under compression, in a compressed condition.

4. Wood absorbs or loses moisture in proportion to the relative humidity of the air, that is, it is a "hygroscopic" material.

5. The rate of movement of water or moisture within the wood itself varies greatly under different conditions. The laws governing this movement are not fully known. It is affected by differences in vapor pressures as well as by capillary action, and in general the transfusion is in the direction of the temperature gradient.

6. The strength and hardness of wood increase with the removal of the hygroscopic moisture. The laws governing this relationship have been very fully determined. But resoaking wood after drying does not restore it to its initial condition when green, the resoaked material being always weaker and more brittle, than the natural undried wood.

7. Shrinkage is different in different directions, being usually twice as great circumferentially as radially and one-fiftieth as much longitudinally.

8. Wood shrinks most when wet and dried slowly at a high humidity and high temperature, and least under the opposite conditions.

9. Brittleness is brought about by long exposure to high temperature.

10. Hygroscopicity, or the property of absorbing moisture from the atmosphere, is slightly decreased but not removed by thorough drying.

From this it will be seen that an unqualified statement as to the shrinkage of different species of wood is almost meaningless, since its amount is dependent upon the factors outlined above. The Laboratory is now undertaking an extensive research on shrinkage and an attempt to determine some of the fundamental laws controlling it.

CARBORUNDUM COATED FIRE-BRICK

THE British Clay Worker, Vol. 29, page 113, discusses a German article on the use of carborundum as a coating for refractory brick. It has been found that with a coating composed of 75 per cent of carborundum and 25 per cent of sodium silicate fire-brick need not be so refractory as without the coating. If the fire-brick are basic, 85 per cent carborundum with 15 per cent of clay may be used and a 0.02 inch coating is sufficient for even the highest temperature. The brick must be thoroughly dry before the coating is applied; it is allowed to dry 24 hours, and is then heated slowly. During this process the coating becomes burned into the brick leaving a firmly adherent glassy veneer of carborundum which resists mechanical injury to a remarkable degree and protects the fire-brick from the chemical action of flames. The coating appears to be insensitive to sudden changes of temperature and in the case of a producer such a coating can be applied to all parts including the fire bars. Gas retorts have been coated inside and out to advantage and where cracks appear they can be repaired with a mixture of 50 per cent carborundum with 50 per cent clay made into a paste.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

DYES AGAIN

Mr. Edward S. Chapin, the Paris representative of the Textile Alliance, Inc., has recently made his report to the Dye Advisory Committee of the Department of State and discusses the situation under four headings, namely, the Herty Option colors, the reparation colors from the impounded stocks, German dye products in the future, and general comments.

It appears from the report that the Germans are laying aside twenty-five per cent of their daily production to be allocated to the Allies in accordance with class and percentage and on the fifteenth of each month submit a statement of the twenty-five per cent due the Allies from their productions of the previous month. Every color produced is included and the price to the Allies is the lowest price quoted during the month of production to any buyer. The following is quoted from the report:

"A brief analysis of the quantitative and qualitative production of the German factories for the past six months will be of interest.

"The total production of the German factories in the month of February, the first month for which a daily production list was submitted, was 1,600 tons, approximately 10 per cent of their pre-war capacity. This production has steadily increased; 2,400 tons in March, 3,300 tons in April, 3,800 tons in May, 4,800 tons in June, and 5,500 tons in July, thus from approximately 10 per cent of their pre-war capacity in the course of six months to 33 1/3 per cent.

"From the standpoint of consumers of dyestuffs in the United States this rapidly increasing production on the part of the German factories is not so satisfactory as might at first appear, for a large part of the increase in production is not the Herty Option colors, the colors desired by the consumers in the United States, but the big bulk colors, the colors that are being made by American manufacturers.

"Take the three months—May, June and July. The total production by all the German factories of vat colors and fast Alizarine colors, which are especially desired by consumers in the United States was approximately 800 tons. During the same period the production of Indigo 20 per cent paste, direct cotton colors, acid colors, and sulphur colors amounted to 8,800 tons, that is to say, eleven times as much as the production of vat colors and fast Alizarine colors.

"Further, while the production of the vat and Alizarine type dye is increasing slowly from 228 tons in May to 261 tons in June and 272 tons in July, the production of the type dyes made in the United States is increasing by leaps and bounds, from 2,400 tons in May to 2,800 tons in June and 3,800 tons in July.

"The large German production of dyes of the same type as are being made in the United States is evidence of the necessity of special protection for the American industry. The relatively small German production of dyes of the Herty Option type explains the 23 per cent of the first six months' allocation orders still to be delivered.

"The question naturally arises whether the Germans cannot produce more of the special colors desired by the United States. The arrangement which is being considered by the Reparation Commission aims to effect this purpose. The Germans do not like the necessity of putting aside 25 per cent of every color which they make during the month for the Allies and especially dislike the necessity of holding this 25 per cent against future orders, more or less problematical. Accordingly the Germans are inclined to consider a permanent proposition which will do away with the necessity of their putting aside 25 per cent of their daily production. The future of the supply of German colors to the United States is linked up with this permanent proposal. According to all indications when I left Europe it seemed almost certain that the permanent proposal would be adopted in the course of a few months."

DETERMINATION OF THE PERMEABILITY TO WATER OF SOLE LEATHER

The following abstract of an article by E. Jalade in *Le Cuir*, IX, 372-77 (1920) occurs in the November Journal of the American Leather Chemists' Association and is interesting in view of the wide application of leathers for service where permeability to water is a major factor:

"The permeability of sole leather is influenced by a number of factors and the effect of the degree of tannage of the leather has already been discussed (that journal, 15, 537-42). It is important to recognize that the degree of tannage is usually greatest in the grain layer and least in the region between grain and flesh. In a sample having a degree of tannage of 73, the degree of tannage of the grain layer was found to be 80, of the flesh layer 62, and of the middle layer only 57. Contrary to the prevailing opinion, the grain is not highly resistant to penetration by water; we found leathers to have the same resistance both before and after the grain had been removed. Bleaching materially increases the permeability of leather to water; a certain make of leather was penetrated by water, under a 20 cm. column, in 50 minutes before bleaching, but in only 5 minutes after bleaching. A false resistance is produced by coating the grain with a drying oil and also by high water-soluble content. A leather containing 21.50 per cent water-soluble matter required 24 hours for penetration, but when this soluble matter was washed out and the leather was again dried, water would penetrate it in 30 minutes. Low degree of tannage, excessive tannage to get high yields, washing after tanning, and bleaching all cause the leather to have poor resistance to water. Few leathers are very resistant. Out of 100 samples examined, 52 were penetrated in less than 30 minutes and only 13 required more than 4 hours."

METALLIC ARSENIC

Pure metallic arsenic is the subject of an interesting discussion of a plant which produces a quantity of metal equal to the requirements of the United States, together with notes on the properties of the metal and its uses by Chester H. Jones in the November 17th issue of *Chemical and Metallurgical Engineering*. The following uses quoted from the article in question will be of interest:

"The metal acts in the nature of a flux for other metals, promoting the union of metals which would otherwise be difficult to mix. The trioxide cannot be successfully substituted for the metallic arsenic in the work. Arsenic bronze, now used for railroad brasses, is a good example. (Composition: Copper 80, tin 10, lead 10, arsenic 8.) The structure remains unchanged, but there is a gain in crushing strength and a lower temperature is required to crystallize. A content of 0.65 metallic arsenic increases the resistance to hammering.

"The arsenic may be added directly to the molten metal, or a rich alloy of arsenic with copper or lead may be made and proper proportions of it used.

"It seems to be the consensus that a small percentage of arsenic added to copper to be used in sheets, tubes, staybolts, etc., for locomotive fireboxes will increase the tensile

strength, rigidity, hardness and resistance to action of gases as compared to pure copper. Added to copper for castings it reduces blow-holes and increases fluidity. Copper to be drawn into wire works better in the drawing process and the melting point and conductivity are lowered.

"The annealing point of copper is raised by the addition of arsenic, and a tougher metal results. The injurious effect of small quantities of bismuth is counteracted. Arsenic tends to deoxidize the copper.

"A higher percentage of lead may be carried in a zinc alloy by the addition of metallic arsenic.

"When added to brass for casting up to 0.5 per cent, it increases the fluidity when molten, gives sharper and cleaner castings and increases the strength and elongation. It increases the ductility of Muntz metal (60 copper, 40 zinc).

"A finer grain and increased hardness is secured by adding metallic arsenic to white bearing metals.

"Arsenical lead contains about 2 per cent arsenic. The product is harder, but the more important property of increased mobility of shot when molten is secured. This results in a more uniform output from the shot tower.

"Metallic arsenic is also used in the manufacture of speculum metal for mirrors in large telescopes."

SPECIAL ALLOYS

A PATENT has been granted to Foster Milliken for three new alloys. One of these is reported to be acid resistant as well as resistant to high temperatures. Its composition is as follows:

Iron	16 to 20%
Chromium	5 to 7
Copper	31 to 38
Nickel	38 to 46
Manganese	½ to ¾

Another is said to be resistant to high temperatures, to alkali and chemical mixtures at such temperatures, and has the following composition:

Copper	50 to 60%
Nickel	28 to 36
Zinc	4 to 8
Iron	4 to 8

The third is recommended for the manufacture of valves, particularly those used in handling gasoline and light petroleum distillates and has the following composition:

Lead	10 to 14%
Copper	55 to 65
Nickel	6 to 11
Zinc	14 to 18

THE MANUFACTURE AND USES OF ROLLED OPTICAL GLASS

THIS is the subject of a report issued by the Geophysical Laboratory reprinted from the American Ceramic Society and reports in detail researches conducted by members of the Laboratory staff during the war period when quantity production of glass suitable for military optics was so imperative. It had long been argued that the method whereby rolled plate glass is prepared could not be applied to the production of optical glass where striae are of such consequence, but it was found that rolled optical glass has the striae in the form of plain parallel films which in general are quite invisible unless viewed edgewise. If optical systems can be prepared from such glass so that the path of light rays cuts the striations in a direction as nearly normal as possible to the directions of the striations themselves no difficulties are encountered in most cases. The paper discusses the method of manufacture which in general is a combinaiton of stirring and earlier processes used in making ordinary optical glass with the casting, annealing, grinding, and polishing, which is common to the manufacture of rolled plate glass. This process was carried out extensively during the war period and produces glass suitable for the majority of optical instruments used in warfare, for spectacles, photographical lenses, field glasses, and low precision instruments in general. No claim is made that rolled optical glass is suitable for optical systems of the highest precision.

THE MALTOSE SYRUP SITUATION

IN *Chemical Age* (New York), October number, there is a discussion of the maltose syrup situation. It will be recalled that many breweries engaged in the manufacture of maltose as a new product employing most of their usual equipment. This was at a time when there was great need for a substitute to supplement the sugar supply and when the price of cereals made competition with the better known glucose much easier than it will be in the future with the decline in the price of such cereals. The industry affords an excellent example of how essential chemical control is to the success of such an enterprise for several producers lacking technical ability have not been able to prepare syrups in quantity equal to samples nor satisfactory for some purposes. On the other hand, maltose syrups today are satisfactory for bakers' uses, for branches of candy manufacture, table syrups, ice cream production and so on. In some beverages it has not been satisfactory, due to the malt taste and some syrups have been too dark in color for certain applications.

Maltose syrup is undoubtedly destined to create a market for itself, based upon its own intrinsic value and because for some applications it is better than its competitor, glucose. There seems no doubt but that maltose is now going through stages similar to those which glucose survived several years ago and as the manufacturers become better able to instruct prospective users of the syrup as to its uses it will undoubtedly gain a firm foothold among the trade. It seems certain that in the future, maltose must be nearly water white, clear, and free from malt odor and taste. This will require scientific supervision and to meet competition there will have to be large scale production.

THE EFFECT OF CERTAIN AGENTS ON THE DEVELOPMENT OF SOME MOLDS

THIS is the subject of a very interesting monograph by K. G. Bitting, bacteriologist of the Glass Containers' Association of America, which has just come from the press. The writer has been engaged in food research for a number of years and during the period has been impressed by the claims of many manufacturers that spices and other condimental agents may be used as preservatives. A series of investigations were undertaken with a variety of such agents using three typical molds and observing the effect upon these organisms of the re-agents used in various amounts. These included the oldest and most generally used, namely, salt, sugar and potassium nitrate, the common spices and aromatics, a series of vegetable acids either found in, or commonly added to, foods such as vinegar, cider, malt, acetic and citric acids, preservatives which have been and are used in foods, including benzoate, alcohol, salicylic acid and the like, certain antiseptics, the mineral acids, two common alkalis and some very active drugs and poisons. So far as could be judged the older preservatives, namely, salt, sugar and potassium nitrate, cause no permanent injury to the molds, the effect produced generally being merely plasmolysis. The spices and aromatic substances of ordinary household use possess in general little or no antiseptic value. All-spice, cinnamon, and cloves show the highest antiseptic values and consequently tests were made to determine the amount of the active principle extracted from each during the process of heating so that more accurate data might be available in judging the preservative action. Reckoned on the amount of spices commonly added to a batch of catsup and the amount of the active principle extracted, it was found in the case of all-spice that the active principle would be present in catsup in the proportion of 1 to 90,000. Authorities give the antiseptic values of oil of all-spice as 1 to 140 and 1 to 180. The antiseptic property of the oil is ascribed to

eugenol which is present in the proportion of 65 per cent thus being present in the batch in the proportion of 1 to something over 138,000.

In the case of cinnamon the active principle present would be in the proportion of 1 to nearly 259,000 and in cassia, the form generally used in place of cinnamon, 1 in nearly 130,000 whereas the highest rating accorded by a scientist is 1 to 2,100. These figures indicate that very little of the antiseptic is obtained ordinarily from the spices in food in which they are cooked for a short period. The spices could be used in amount sufficient to heighten antiseptic effect but the great concentration of flavor would be intolerable.

Interesting summaries accompanied by detailed tables are given for all seven groups of materials employed as well as for mixtures of the re-agents and the monograph concludes with an extensive section of photomicrographs showing the state of the molds in question after incubation in tomato bouillon or other media to which various proportions of the re-agents were added.

SOURCES AND PRODUCTION OF IRON

ATTENTION is called to the 1918 report on the sources and production of iron and other metalliferous ores in the steel industry, this having been compiled under the direction of the Department of Scientific and Industrial Research of Great Britain. The report is in three parts, the first consisting of notes on the iron ores of the United Kingdom and British Dominions, the second on the iron ore deposits in foreign countries, and the third, notes on the ores of the principal metals other than iron used in the iron and steel industries. The statistics of production of iron ore are given by the counties of Great Britain and Ireland and in considerable detail for all of the British Dominions. These details give something of the history of the particular deposit, an indication of the geology of the region, the types of iron ore to be found there and placement in the region, and an analysis of the typical ores. In some instances ownership is indicated and the annual production is also included. In instances where returns are incomplete this is noted. Frequently the analyses are complete and should be of considerable reference value.

As for the foreign countries, all are included insofar as the data has been published. In fact, the available resources of a particular country are summarized and frequently import and export data are given. The ores of metals other than iron used in the iron and steel industries are given as chromite, ferrochrome, cobalt, manganese, manganiferous ore, ferromanganese, molybdenite, ferromolybdenum, nickel, titanium, titaniferous ores, ferrotitanium, metallic titanium, tungsten in its different forms, vanadium, ferrovanadium and zirconium.

This information is treated geographically; characteristics, world production, and prices are included. In the case of zirconium a short bibliography of principal articles and papers on the subject is furnished. The report is to be obtained from H. M. Stationery Office, Imperial House, Kingsway, London, West Central 2, the price being two shillings.

COLLOIDAL FUEL

AT the last meeting of the American Chemical Society, Dr. Shepard of the Eastman Kodak Company presented an important paper on colloidal fuel which has been discussed so much of late. In extensive tests, this fuel gave results equal to naval fuel oil and was found satisfactory on submarines even after three or four months' storage. On the average this fuel contained 31 per cent of pulverized coal and yet possessed the properties and flexibility of oil being capable of handling like oil and possessing its flexibility for manufacturing purposes. Various grades of carbon material may be employed, realizing an economy of from 25 to 50 per cent of the oil used. This fuel has very little moisture or ash and is as compact as oil but with more heat units per gallon. It is not subject to spontaneous combustion, does not generate explosive vapors, and can be water-sealed in storage and water-quenched when ignited. This makes its fire risk as low as anthracite. Its combustion efficiency in steam raising per British Thermal Unit per pound is said to be equal to fuel oil and its method of preparation has been so perfected that its life in storage is from one week to one year, according to the grade. By life is meant the length of time which it can be stored without a separation of the pulverized coal or other carbonaceous material from the oil in which it is suspended.

WATCH OILS

THE oil which has heretofore been considered satisfactory for the lubrication of time pieces has been prepared almost entirely from the maxillary fat accumulations of the porpoise. There has been some oil prepared from other fish and such oil has sold for about $250 per gallon. Dr. C. F. Mabery has now perfected a process whereby a satisfactory grade of lubricating oil for watches and clocks and other fine mechanisms can be prepared from crude petroleum. His experiments thus far have been on oil from the Mecca field and a company in Ohio has begun the production of this high grade product on a commercial scale.

HYDROGEN

A PATENT has been granted to the British Oxygen Company for a new process of preparing hydrogen. Ordinarily hydrogen has been prepared by the iron-steam process in which the waste gases of reduction have not been fully spent in passing through a retort. These gases, which still contain reducing gases, are to be treated by the new process for the removal of the steam and some water vapor, carbon dioxide and sulphur dioxide, and other sulphur compounds, after which it is passed to another retort where it effects the reduction of the charge in it. The waste gases may be passed into the furnace setting or discharged into the atmosphere. The process may be carried out with three sets of retorts operated so that while the first is making hydrogen, the second may be receiving water gas to completely reduce the charge in it, and the spent gases from this set after treatment as described may be passed to the third set. The next step would be for the second set to make hydrogen while the others take up the cycle in the order named above. The purification of the spent gases is effected by first passing them through a scrubber packed with marble and coke down which water trickles to remove the sulphur, then washing to remove carbon dioxide and finally passing them through a condenser to remove steam and water vapor.

CHANGES IN CYANAMID

IN the November issue of the *Journal of Industrial and Engineering Chemistry* there appears a paper by N. R. Harger on the changes taking place in cyanamid when mixed with fertilizer material. A great deal of research has been done on changes which take place when cyanamid alone is added to the soil or is kept in storage, but relatively little attention has been paid to changes which may occur in the material when this extremely reactive substance is mixed with the other fertilizer materials. There has been indication in some areas that mixed fertilizer containing cyanamid is somewhat toxic to plants but heretofore no experiments on the question have been reported. In the experiments under discussion the following mixtures were used (1) acid phosphate and cyanamid; (2) potassium sulfate, acid phosphate, and cyanamid; (3) ammonium sulfate, acid phosphate, and cyanamid; and (4) dried peat, acid phosphate, and cyanamid. The paper discusses the chemical changes involved and gives experimental details together with analysis, the author having devised a rapid method which is direct, for the determination of dicyanodiamide which has been found to be the substance into which cyanamid is changed under the conditions obtained. While further investigations are under way the results which so far have been ascertained lead the author to reach the following conclusions:

1. When cyanamid is mixed with fertilizer materials con-

taining acid phosphate and 5 to 10 per cent of moisture, the cyanamid content decreases with great rapidity.

"2. This change is represented partially by, and in the higher concentrations principally by, the formation of dicyanodiamide.

"3. A given quantity of moist acid phosphate is able to transform a limited amount of calcium cyanamide.

"4. Cyanamid is not affected by dry acid phosphate.

"5. Moisture alone is able to cause the conversion of cyanamide to dicyanodiamide, but the change is much slower than when acid phosphate is present.

"Since it has been repeatedly shown that dicyanodiamide is valueless as a fertilizer material, and, moreover, is toxic to many plants, the formation of this compound in fertilizer materials seems undesirable. On first thought, it would appear that this conversion of cyanamide into dicyanodiamide could be avoided by employing dry fertilizer mixtures, but this overlooks the fact that when such mixtures are added to the soil, moisture conditions are at once provided, and the transformation may possibly then take place. Preliminary experiments carried out in this laboratory indicate that, under certain conditions at least, this is the case.

"It should be noted that these unfortunate reactions between acid phosphate and cyanamid do not in any sense imply that cyanamid cannot be successfully used when mixed with other forms of phosphate. In this connection it should be noted that the Fixed Nitrogen Research Laboratory of the Ordnance Department has called our attention to the fact that lime nitrogen (cyanamid) can be mixed with calcined and basic phosphates without the excessive production of dicyanodiamide noted when moist acid phosphate is used."

THE AMERICAN INSTITUTE OF BAKING

The American Institute of Baking has issued its first annual report which gives details as to progress made in organizing and establishing this new research body which brings to the aid of one of our oldest industries the assistance which modern science affords. There have been individual instances where the larger bakeries have called science into the workroom and the progress resulting has been a factor in persuading the bakers in general to accept such assistance. Besides enjoying the assistance of an advisory board composed of eminent specialists appointed by the National Research Council, the Institute has benefited by an arrangement with the University of Minnesota by which students in the graduate school, candidates for advanced degrees, and who are interested in problems which concern wheat fermentation, gluten development or other problems with a practical application to the baking of bread may conduct their work in the laboratory of the American Institute of Baking. A baker's short course has been devised and one important function of the Institute is to afford means for specialized training for those engaged in the industry. The literature of breads, yeasts and fermentation, as well as of cereals and the baking industry in general is being compiled with the aid of the indices of the Library of Congress, Bureau of Chemistry, and the Department of Agriculture, and extensive steps are being taken for complete coöperation with other interested associations.

The work thus far undertaken involves standardizing baking materials and preparing specifications upon which they may be purchased, which is in itself a very large problem since such materials as flours are indeed difficult to standardize. However, standards have been established by state and federal departments for such substances as oil, fats, lard, condensed and dried milk, sugar, and hydrolized starch products. Some other interesting questions are: what is an ideal loaf of bread and is it possible to standardize the loaf? For ages a loaf of bread has been simply a loaf of bread and there have been no units by which it could be standardized. The products of a number of successful bakers, if brought together, would be quite dissimilar as to shape, size, weight, color, flavor, texture, crust and crumb. Problems which at present confront the Institute include a study of rope infection in bread and its control, a study of acidity control in bread making and its relation to length of fermentation, composition and enzymic activity of malt preparations, methods of analysis, moisture retention and staleness, and a study of the methods and materials used in the wrapping of bread and the effect of these materials upon the content and package. Advice is being given the industry on shop problems and raw materials are being analyzed.

PRICKLY PEAR

The Journal of Industries, which is issued by the authority of the Minister of Mines of Industry of the Union of South Africa, in the September number gives the second of the articles by Dr. Juritz on the prickly pear and the possibility of its utilization. The author has already discussed in other publications the possibility of using the prickly pear as a source of industrial alcohol. To make alcohol production from this source profitable it would appear necessary to produce a large amount of fruit from small areas which, to make collection economic, should bear ten tons of fruit to the acre. There would also have to be devised a less expensive method of collecting than hand picking. This question, by the way, has already been investigated in New Mexico and the problem appears to be only one of economics. There is a possibility of certain species of prickly pears being used for the sake of a mucilaginous substance which can be obtained from it. It is also suggested as a source of oxalic acid, since crystals of calcium oxalate are contained in all parts of the plant in comparatively large proportions and some other oxalates are to be found in the liquid condition. The prickly pear is also suggested for paper making, but the pulp which has so far been prepared in experiments appears to consist of short fibers which would have a low value and as is so often the case with such plants, the yield per ton of raw material is small and the amount of re-agents required relatively great.

A dye or coloring matter of a light magenta shade can be extracted without difficulty from fruits of certain kinds of prickly pear and this dye from the species which occur on the high mountains of Argentina has been used locally for dyeing wool. There is, however, a great deal of research necessary before recommendation for commercial venture in this field could be made. As a source of oil the great difficulty appears to be again in the collection of material and the low percentage of oil in the seeds of the plant would appear to make it commercially impossible. The plant has also been suggested as a basis for soap manufacture, but there is nothing to indicate that this suggestion can be considered seriously. The article concludes with a number of minor uses, but such applications as are named are not such as to encourage any commercial development.

ARTIFICIAL WOOLENS

In the *Color Trade Journal* for September a note from the Textile Mercury on imitation woolens appears. The treatment has been patented in England and is designed to impart to vegetable fibers appearance, feel, and chemical and physical properties resembling woolens. The cotton is impregnated by means of a solution of cellulose in concentrated nitric acid and then treated with water to precipitate upon the fibers a slightly nitrated cellulose. After pressing and washing the nitro cellulose remains firmly adherent to the fiber. Its treatment increases the weight of the material and renders it possible to absorb a greater quantity of basic colors.

An example of operating according to the patent is to introduce rapidly and with constant stirring thirty grams of cotton waste or wood pulp thoroughly disintegrated and bleached into a thousand grams of 81 per cent of nitric acid at a temperature of 15 to 20°C. When the mixture has become a syrupy mass add 110 grams of water. Allow this solution to cool and then immerse in it the fibers or material to be treated, allowing it to remain for a time without tension; then squeeze and wash.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

SOME RECENT APPLICATIONS OF THE AUDION

MR. LEE DE FOREST, reviewing the development of the audion in an extensive paper read before the Franklin Institute, brings out some very interesting applications of this apparatus and forecasts the use of it in many new directions. Most striking is the suggestion of producing music electrically. To quote the author: "The uniform generation of electrical oscillations in a circuit by means of an audion is one of the most fascinating of its applications. If these are of radio frequency there is no sensible manifestation of their presence, but if of audio-frequency the telephone receiver or "loud speaker" reproducer may be made to give forth sounds from the highest pitch or volume to the softest and most soothing tones. Such wide range and variety of tone can be produced from suitably designed singing circuits that a few years ago I prophesied that at some future time a musical instrument, involving audions instead of strings or pipes, and batteries in place of air, would be created by the musicians' skill."

There seems to be no limit to the number of applications to which the audion can be applied as a tool in the hands of the experimental physicist. Very recently Prof. Blondel has utilized the audion in a balanced bridge method for measuring excessively slight differences in static potentials. Again, as low frequencies, even to one oscillation per second can be obtained from the audion, pulsations suitable for submarine cable signaling, or for chronograph and time-pendulum work, can be had of remarkable constancy and reliability, free from all difficulties of speed regulation of motors, or of any moving parts. Of especial value is the fact that it renders easily available devices having negative electrical resistance, as in the four-electrode device of Dr. Hull; for one fundamental property of the audion is that an electrical influence in one circuit may, through the grid, be made top roduce effects in another circuit without appreciable reaction. The energy absorbed by the control electrode may be considered negligible—frequently less than that required in moving a galvanometer needle. Then, and probably the most promising field of all, the arrangement of audions in cascade as amplifiers of pulsating currents of any form or frequency opens to the ear what the microscope has given to the eye—new regions of research in numerous and diversified fields, from physiology, for heart beats and breath sounds, to chemistry, where some even predict that we shall some day hear "the collision of individual atoms with one another."

DAYLIGHT BIOSCOPE PERFORMANCES

REPEATED attempts have been made lately to obviate the necessity of a darkened auditorium for bioscope performances. Fortunately, some of these attempts have been crowned with success, and some apparatus have been devised which may now enter into competition with the old appliances requiring "lights out" for the performance. The study of the problem before the inventor soon made it evident that two solutions only were possible: either the picture had to be reflected by an opaque screen as heretofore or by a transparent one with the operator behind it. The adoption of the latter alternative, however, found most favor and success, and the desiderata for its execution can be described briefly as follows: (1) The picture must show sufficiently bright and distinct, even with the daylight or artificial light upon it. (2) Evenness of the screen and sufficient fineness of grain. (3) Clear and brilliant white tints of the picture. (4) Uniform diffusion of the light rays of the projector lamp, to ensure an even illumination. (5) Perfect smoothness of the screen.

The "Daylight screen" of the Deutsche Lichtbild-Gesellschaft meets all these demands to their fullest extent. Under reflected light the screen shows a deep black color which perfectly absorbs all light rays, whereas, under transparent light a clear white color appears, which even in the glare of daylight produces a picture, distinct luminous and exceptionally brilliant. The rays of the projector lamp are so well and so regularly diffused that not only a perfectly even luminosity of the screen but also an absolute invisibility of the light source has been attained.

This result can be arrived at in two different ways. Either the apparatus is connected with the screen by a tube which carefully excludes every bit of light from the outside or a dark room is built on the stage behind the screen. Both tube and dark room serve to exclude all possibility of light coming in from the outside. The former type is mostly adapted to schools, private entertainments, etc. In this case a bellows is attached to the apparatus permitting of a very accurate focusing of the picture. The second type is usually employed at theaters or theatrical performances; here the transparent screen is suspended close to the footlights, while from the stage itself all light from the outside is carefully barred by black curtains. When the screen is not in actual use it is raised like the ordinary curtain, thus freeing the stage for other entertainments. Should the space behind the screen prove too short for the installation of a dark room, it may yet be adapted for the use of the daylight screen, inasmuch as the focal distance can be increased by first throwing the light rays from the projector lamp vertically upward on a mirror fixed above at an angle of 45 degrees, and from there by way of another mirror fixed at the same angle, on to the screen.

There can be little or no doubt that the apparatus described above will considerably extend the scope of cinematography. It will be of special service to the teacher who may have to watch his pupils during the performance. To enable him to do this or to interrupt the performance suddenly for the purpose of explaining the picture, a special, skilfully worked out stopping device has been attached to the projector lamp which permits him to arrest the moving picture at any given moment. For advertising and entertaining of any kind this new apparatus will in the future be found quite indispensable. —*Engineering Progress*, July-August, 1920.

THURY SYSTEM OF DIRECT CURRENT TRANSMISSION

IN *General Electric Review* for November, 1915, Mr. William Baum gave an exhaustive review of the Thury system and its European installations. Interest in this system has not been lacking also in this country. Of timely interest is, therefore, the article by Prof. Alfred Still in *Electrical Review*, Chicago, for August 7, 1920, briefly describing its advantages and disadvantages.

In Europe underground cables are usually preferred to overhead wires when the distance of transmission is not great, and the Thury system is used in about 16 independent transmission systems utilizing direct-current pressures up to 100,000 volts. The high voltage is obtained by connecting a number of generators in series; the pressure across any one commutator does not exceed 5,000 volts. While not going into details of this system, the author believes that occasions may arise, even in this country, where its peculiar advantages over the alternating-current system may lead to its adoption, provided the engineer will have an open mind and refuse to be governed by custom and prejudice.

The advantages of the Thury system are as follows: (1) The

power-factory is unity—a fact which alone accounts for considerable reduction of transmission losses. (2) Higher pressures can be used than with alternating current, the conditions, as shown by actual tests, being more favorable to direct-current transmission than is generally supposed. Without any alteration to insulation or spacing of wires, approximately double the working pressure can be used if direct-current is substituted for alternating-current. (3) The necessity of two wires only, in place of three, effects a saving in the number of insulators required and leads to cheaper line construction. (4) Where it is necessary to transmit power by underground cables, continuous currents have great advantages over alternating currents. Single-core cables can be made to work with continuous currents at 100,000 volts. By using two such cables and grounding the middle point of the system it is, therefore, quite feasible to transmit underground at 200,000 volts. (5) There are no induction or capacity troubles and no surges or abnormal pressure rises due to resonance and similar causes, such as have been experienced with alternating currents. A number of generating stations can easily be operated in series, and when the demand for power increases, a new generating station can be put up on any part of the line if it is inconvenient to enlarge the original power station. (6) The simplicity and relatively low cost of switch-gear is remarkable. A switch pillar with ammeter, volt meter and four-point switch is all the necessary equipment for a generator. The switch pillar for a motor includes, in addition, an automatic "by-pass" which bridges the motor terminals in the event of an excessive pressure rise. This compares very favorably with the ever-increasing, though in some cases unnecessary, complication and high cost of the switching arrangements in high-tension power stations on parallel systems. (7) For any industrial operation requiring a variable-speed drive at constant torque, the Thury motor, without constant-speed regulator, is admirably adapted. It might have a useful application in the driving of generators supplying constant current to electric furnaces in which the voltage across the electrodes is continually varying.

The disadvantages of the Thury system are: (1) The relative smallness of the generators is objectionable, the output of each generator being limited by the line current and the permissible voltage between the collecting brushes on the commutator. (2) With constant current on the line, the line losses are the same at all loads, and the percentage power loss in the conductors is inversely proportional to the load. This is exactly the reverse of what occurs on the alternating-current parallel system, in which the percentage line loss is directly proportional to the load. (3) The series system is less suitable than the parallel system for distribution of power in the neighborhood of the generating station. It is essentially a transmission system, and not a distributing system. (4) Special regulating devices are necessary to maintain constant speed on the motors. (5) It is impossible to overload the motor, even for short periods. This would be a very serious objection to the use of these motors in connection with electric traction systems.

ELECTRICALLY-OPERATED STEAM BOILERS

BASED upon the existing conditions of high fuel costs and cheap surplus hydro-electric power, numbers of Swiss manufacturers have introduced electrically-heated steam generators. Some of these have been in operation for several years. A typical generator of this type is the "Revel" boiler, manufactured by the Escher Wyss & Co., Zurich, Switzerland. The main features of this type of boiler are the stationary diving-electrodes which penetrate the cover of the apparatus through openings. The cover is removable. The boilers are of compact construction so that they are subject to but trifling losses of heat due to radiation. The delivery of electrical current to the boiler is regulated according to the quantity of steam required, and is easily arrived at by simply varying or lowering the water level of the boiler. Steam production can be continuously and easily regulated within the extreme limits of capacity of the boiler. After a lowering of the water level, the boiler still remaining under pressure, if the steam stop valve has been closed, the generator absorbs a quantity of electrical energy exactly in accordance with the losses due to radiation of heat, and is always ready for further extraction of steam. Even a low water level in the boiler does not involve any danger, as in the case with ordinary fixed boilers. The lowering of the water level in the boiler is, for the Revel type, a feature of normal working operation.

The performance of a typical Revel boiler is, according to tests conducted by the Swiss Association of Boiler Proprietors, as follows: One kw.-hr. converted 2.83 pounds of water from 50° F. into steam 212° F., and therefore the efficiency of evaporation was 95.7 per cent. The electrical energy used was only 146.7 kw. per hour, although the boiler had been designed for a capacity of 200 kw. The variation in steam pressure was trifling during the tests, and the removal or extraction of steam remained practically constant. The quantity of water entrained during the evaporation was very small —2 to 3 per cent.

Another valuable feature of such an installation is the possibility of utilizing for steam production only the current available at night, storing up the heat in storage boilers. A typical installation works as follows: In the evening when the water turbine of a hydro-electric plant is free to drive the electrical generator, the current produced by the latter is given to the Revel boiler. The steam produced by the Revel boiler is carried by piping into the water contained in the steam storage boilers where it is condensed, thus heating and super-heating the water. The storage boilers are built for 180 pounds per square inch working pressure and 270 pounds per square inch test pressure and are insulated with a double cover of insulated stones. During the night the temperature of the steam storage boilers gets higher and higher, as does the steam pressure and the level of the water. The Revel boiler itself is kept under a constant working pressure of about 165 pounds per square inch by means of a simple automatic device. In the morning the storage boilers are filled up under high pressure and are ready to give steam. The Revel boilers is then disconnected, so that the water turbine may do its day's work by driving the main transmission shaft of the plant. The steam consumption required by the plant is provided during the whole day by the steam taken from the storage boilers. This daily running of the installation is called the discharge of the storage boilers. At noon the discharge may be interrupted by a short recharging. In the afternoon the discharge is continued, and in the evening the cycle is repeated.—E. G. Constam-Gull, *Canadian Engineer*, August 12, 1920; also *Power*, October 12, 1920.

Other references: (1) Boselli, Storage of heat in electrically-heated boilers.—*Elettrotecnica*, June 25, 1920.

The efficiency of the installation would depend upon the heat radiated from the boilers between the period of accumulation and that of discharge. The author estimates that the heat radiated could be reduced to 15 kg. col. per hour per degree of difference of temperature between the boiler and the air.

(2) On the utility of adding energy accumulators to hydro-electric plants.—*Revue Générale de l'Electricité*, October 23, 1920.

MAGNESIUM

THE apparatus used in the production of magnesium is not very different from that used in aluminum and consists of a cell in which anhydrous magnesium chloride is kept in a state of fusion, using a direct-current. After the chloride is molten, the electrolytic action then separates the elements, and metallic magnesium is deposited at the cathode in a molten condition. The reaction involved is simply the dissociation of the chlorine and magnesium by means of electric current. This requires approximately 25 kw.-hr. per pound of metallic magnesium. The character of this load is of course very

uniform and steady, and is in all respects similar to any other electrolytic load. The industry being new, and the process intricate, many improvements are possible in the apparatus for producing this metal.

The tensile strength of magnesium is about twice that of aluminum, and the field offered for expansion is now in the manufacture of magnesium alloys, where light, strong material is needed. It is claimed that these alloys are very easy to turn, thread, file or polish, and that they are not easily attacked by dilute acids, as is ordinary aluminum, and keep their polish better in the atmosphere than aluminum. It is not at all impossible that, due to these very favorable characteristics, when the process is so improved that the cost of production is somewhere near aluminum, this metal will replace the aluminum-copper alloys now used in vacuum cleaners, automobile parts, typewriter frames, crank-cases, etc.

A very promising application of aluminum magnesium alloy is for hydraulic valves and fittings, as well as for certain electrical fittings which formerly have been made of brass and bronze. An alloy containing 96 per cent of aluminum, 2 per cent of magnesium and 2 per cent copper costs about one-half as much per unit of volume as brass. It can be readily seen, therefore, that where requirements are such that strength is of more importance than current-carrying capacity, there are many places where this alloy will be used to replace brass. The future development of the magnesium industry will be around cheap water power. This is because the reduction of magnesium requires such a large amount of power per pound and is one of the largest factors in the cost of manufacturing this metal.—C. A. Winder, Proceedings of the *National Electric Light Association*, May, 1920.

HALF-WAVE AND QUARTER-WAVE TRANSMISSION LINES

A NUMBER of contributions have appeared in the French technical press discussing the possibilities of transmission lines which are electrically a quarter-wave or half-wave in length. In *Revue Générale de l'Electricité* for March 20, 1920, Mr. P. Bunet states that we are at present limited to transmission lines of about 500 km. at a pressure of 100,000 volts per phase. Much longer transmission lines would require a considerable increase of pressure at the beginning of the line in order to take care of the voltage drop and keep the pressure constant at the end of the line. As the inductance and capacity of the line vary with the diameter, no improvement can be obtained by increasing the size of the wires. The author then shows that a line electrically a quarter-wave in length allows the transmission of power to greater distances. Such a line is resonant to the frequency employed, so that for each particular length of line a definite frequency should be employed. Thus, with the ordinary aerial lines the frequency of 50 should be used for a distance of 1,500 km. and the frequency of 25 for a distance of 3,000 km. If the resistance of the line were zero, the pressure at the end of the line would be rigorously constant, if fed at the beginning at rigorously constant current intensity. In practice the resistance of the line necessitates adjusting the current intensity at its beginning, but, because of the resonance, no voltage drop will be caused either by the inductance or by the capacity of the line. The power factor of the energy-utilizing apparatus has no influence upon the regulation of such intensity. Taking a concrete example of a line 1,200 km. long, fed at 50 periods per second, transmitting 75,000 kw. at 100,000 volts per phase at end, the author shows that the current intensity at the departure extremity must vary from 265 to 295 amps. between no load and maximum load; the efficiency between half load and full load is practically constant—about 82 per cent.

The main disadvantage of such a system consists in the necessity of using constant current alternators which have not been yet been studied and constructed. Therefore, Mr. E. Brylinki proposes (*Comptes Rendus*, for April 19, 1920; also *Bull. de. la Soc. Franç Élect* for May, 1920) the use of lines half a wave long for which the usual type of alternator can be used. In these lines the electricity takes half a period to flow from one end of the line to the other. For a frequency of 50 this corresponds to a length of about 3000 km. This length may be diminished by inserting coils, and thus increasing the inductance, or by inserting stretches of buried insulated cable, thus increasing the capacity. The author also gives practical examples of applications of half-wave transmission lines.

ELECTRICAL DEHYDRATION OF OIL

IN order to be salable, or classed as "pipe line" oil and accepted by the transporting companies, a crude oil must contain no more than 2 per cent water. That the necessary process of dehydration can be accomplished by electricity with remarkable efficiency and economy has been shown in recent contributions on this subject.

Mr. J. L. Sherrick writing in the *Journal of Industrial and Engineering Chemistry* for February, 1920, on Oil-field Emulsion, gives a brief review of the development of electrical dehydration. The pioneer patent in the electrical treatment of oil-field emulsions was taken out by F. G. Cottrell (U. S. patent 87115). This process depends for the demulsification upon the action of high potential alternating current electricity. The water is dispersed as finely divided globules throughout the oils and these are caused to coalesce by the action of electrostatic forces. The Petroleum Rectifying Company of California, operating under this and other patents, has installed a number of plants in California, Oklahoma and Kansas.

Another process consists in passing the emulsion between electrodes connected to a source of direct current with a potential of 250 to 400 volts, with a current varying from a few milli-amperes to ten amperes. The patent under which the direct current electrical treatment is operated (U. S. patent No. 1,290,369) claims that the process depends upon cataphoresis on electrical migration. Here may also be mentioned the patents of McKibben (U. S. patent No. 1,299,589 and No. 1,299,590 of 1919) who passes the emulsion of petroleum and water, heated sufficiently to produce vaporization, through an intensified electrical field. The vapors are condensed and cooled, and the water drops out.

Mr. H. N. Sessions describes in *Journal of Electricity* for October 1, 1919, some installations in the Whittier district. The usual electrical dehydrating plant is made up of four treaters and operates on a single-phase alternating current at a pressure of 11,000 volts. In certain leases where water is very scarce, the water electrically removed from the oil is of considerable value. Due to the condenser effect caused by the highly charged electrodes the electric dehydrator operates at about 98 per cent leading power factor. The advantages of electrical dehydration may be summarized as follows: The electrical process leaves the oil its natural color, while the heating process impairs its market value by discoloring it; the heating process requires close watching, the electric practically none. The low fire hazard with electricity is also important. The electric dehydrator effectively treats oils of different grades at the same time without in any way impairing their efficiency. Oil containing eighty-five per cent emulsion has been successfully dehydrated electrically. The electric process causes practically no loss of gasoline, and the records show that after treatment the gravity of the oil has been raised from one to two degrees and has in consequence an increased market value. A record run of 7,000 barrels of the same grade of crude oil was made, first by the heating process, then by the electrical. Eighteen hours was required with heat and only 7.5 hours with electricity, the net amount of the oil being 5,060 barrels with the former process and 5,160 with the latter. The total cost by the heat process for the run was $387 or 7½ cents per barrel, while the entire expense with electricity, even including a royalty of half a cent per barrel, was $102, or slightly less than 2 cents per barrel.

CONSTRUCTION OF THERMO-COUPLES BY ELECTRODEPOSITION

Although thermo-electric appliances have been used in one form or another for nearly a century, the method of constructing these remained practically unaltered—namely, joining together with solder two metals suitably related to one another in the thermo-electric series.

In practice this method has several serious drawbacks which may be briefly stated as follows: (1) It is difficult to form reliable joints between dissimilar metals which will withstand working at high temperatures without deterioration. (2) The maximum working temperature is determined by the melting point of the solder. (3) Owing to the extreme difficulty in making such joints between very small wires it is impossible to reduce the mass of the metal at the points to the extent which is necessary for some special purposes. (4) The labor and difficulty of constructing a large number of junctions to operate in series is excessive; it becomes impracticable when the size of the wires is small.

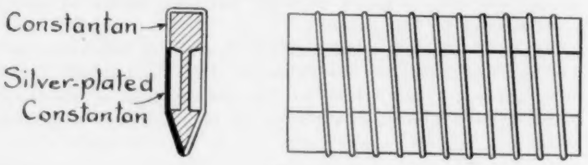


FIG. 1

The new method which was devised to overcome the above mentioned drawbacks consists in using a continuous wire of one of the elements and coating those parts of it which have to form the other element with an electrolytic deposit of another metal. If the conductivity of the latter is considerably greater than of the former, and a fairly thick sheath is deposited, a thermo-couple is produced which is not appreciably impaired in efficiency by the short-circuiting effect of the core. Constantan wires coated with either copper or silver sheath were found to be suitable for most purposes.

For a line of junctions the arrangement shown in Fig. 1 was found satisfactory. In this the core was of ebonite, hollowed out to facilitate cooling, and the conductor consisted of silver-plated constantan strip about 0.008 inch by 0.00075 inch. Sixty junctions had a resistance of 85 ohms. Mica was found more convenient than ebonite for many purposes; however, the presence of any insulating material near the hot junctions materially lowered their temperature, besides rendering their action more sluggish. The arrangement for mounting the junctions shown in Fig. 2 was therefore adopted, whereby the proximity of insulating material to the junctions is avoided.

Another useful arrangement consists of two lines of junctions connected in opposition and arranged close together as shown in Fig. 3. Since the number of junctions in each line may be made large, the deflection of the galvanometer G may be made substantially proportional to the movement of the band of radiant heat. The arrangement, therefore, comprises a useful means of magnifying small movements.

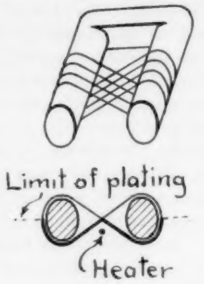


FIG. 2

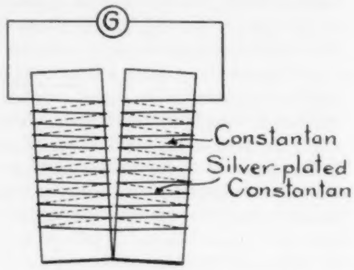


FIG. 3

In the discussion it was brought out that there were many cases in which this device would be of greatest service to physicists, in the measurement of radiation, for instance. It was mentioned that Prof. Hill, of Cambridge, has recently been measuring the rise of temperature of nerves in action by means of these couples. It was also suggested that the method might enable a radiation pyrometer, similar to the Féry type, to be made for the measurement of low surface temperatures. The device is also useful for spectro-radiation work, as the total breadth could be made very small and a large number of junctions per centimeter employed.—Wm. H. Wilson and Miss T. D. Epps, *Proceedings of the Physical Society of London*, August 15, 1920, v. 32, p. 326-40.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

THE ULTRA-MICROMETER

By Prof. R. Whiddington

Not so long ago working "to a hair's breadth" was considered quite an achievement. Then, the thousandth of an inch became a fairly common limit of precision in machine work, and a thousandth of an inch is only a fraction of a hair's breadth. It had been found, however, that in order to permit work to a thousandth of an inch the gages had to be made far more precise, and various methods, in particular the so-called interferometer methods of measurement, were developed, permitting a precision as high as one-millionth of an inch.

Interferometer methods, however, are limited in accuracy of measurement by the wave lengths of light used in the production of the fringes. It is not always easy to see at once where precision of measurement in excess of a millionth of an inch may be required, but in scientific work there are already cases where a higher precision is desirable. The ultramicrometer, a new device, permits measurement to the scarcely creditable precision of one-two hundredth of a millionth of an inch. As an idea of what one-two hundredth of a millionth part of an inch means, it may be said that it bears very roughly the same relation to one inch that one inch bears to the distance by rail between New York and San Francisco.

The new measuring apparatus is based on the fact that if an electric circuit, consisting of a parallel-plate condenser and inductance, be maintained in oscillation by means of a thermionic valve, a small change in distance between the plates produces a change in the frequency of the oscillations which can be accurately determined by certain methods. The sensitiveness of the apparatus is extremely high.

The theory of the method is comparatively simple. If a capacity C be connected to an inductance L, the frequency of oscillation N natural to the circuit is given by

$$N = \frac{1}{2\pi\sqrt{LC}}$$

If the condenser be composed of two parallel plates of area A separated by distance x, then the capacity C is determined by the equation

$$C = \frac{A}{4\pi x}$$

If we substitute this value C into the above equation for N, we obtain

$$N = \left(\frac{x}{\pi LA}\right)^{1/2}$$

which shows that a change in distance x between the plates produces a change in the frequency of oscillations N, so that

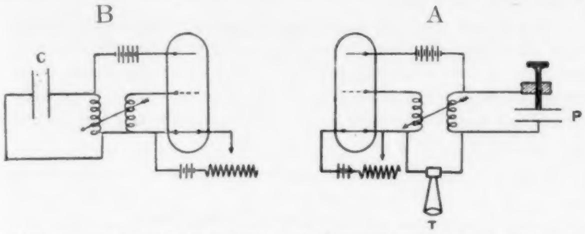


FIG. 1. DIAGRAM OF MAIN ELECTRICAL ELEMENTS IN THE WHIDDINGTON ULTRA-MICROMETER

inversely a change N may be taken as an indication of a change in x.

On the basis of this theory was built the apparatus shown in Fig. 1. In this diagram A is the oscillating valve circuit involving a parallel-plate condenser P; T is a loud-speaking telephone, shown for simplicity directly inserted in the valve-anode circuit, although in actual practice an amplifier intervenes.

The values of the coils in the grid and anode circuits of the thermionic valve were so chosen as to produce oscillations N of about a million frequency. In order to bring about any change in N a second valve circuit B was set up close to the circuit A. The frequency of this circuit could be adjusted by means of the condenser C so as to be nearly but not quite equal to N. This produced a loud audible note in T, the frequency of which could be adjusted to any desired value by a suitable choice of C. Another valve circuit was provided with proper capacities and inductance in order to provide a constant standard of pitch to which the note in T could be adjusted. This additional circuit is now shown in Fig. 1.

As regards the sensitiveness of the apparatus, it may be mentioned that the bending of a very substantial table, produced by an English penny coin laid on its edge, was clearly indicated by a change in the note from the telephone T.

The details of the method of measuring are not given. The method has been of service, however, by proving that Hooke's law was obeyed to the limits of accuracy set by a micrometer capable of measuring to 10^{-4} inch.—*London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*, Vol. 40, No. 239, Nov., 1920, pp. 634-639.

HELICAL SPRINGS

By W. Norman Thomas

It has been observed that in practice many springs fail under smaller loads than those for which they were originally designed. Investigation shows that there are two considerations which may easily be overlooked in the design and use of a spring, namely, (1) the effect of eccentricity of the load, and (2) the effect of the direct shear stress as distinct from the torsional shear stress in the material of the spring. Failure may be due either to entirely overlooking these two points, or, more often, to underestimation of the magnitude of the applied loads and of the effects of impact and repetition of stress. In a considerable number of cases failure may be due to the fact that the springs were designed for normal-temperature work and then afterward employed under very high- or very low-temperature conditions.

Equations are developed for the design of close-coiled springs and open-coiled helical springs, and curves are given, among other things, showing the bending and twisting moments in various parts of springs for different eccentricities of load, and the maximum principal stress and the maximum shear stress at the extremities of the vertical diameter of the cross-section of the wire. From these equations it appears that for the same value of M (eccentricity) the deflection is smaller with an open-coiled spring than a close-coiled spring containing the same length of wire. If the number of coils is the same for each spring, then for the same value of M the deflection is greater with an open-coiled spring than with a close-coiled spring. In addition to this, the values of the stresses in the wire calculated by the various formulae given in the article are tabulated and plotted in Fig. 2. From these it would appear that unless the load is axially applied upon a spring, the stresses may be considerably greater than those for which the spring was designed.

Thus, in an example worked out in the original article, 665 W would represent the load for which the spring was probably designed, that is, assuming axial loading and neglecting the direct shear stress, whereas the maximum shear stress even with axial loading is 721 W, and the maximum principal stress f_1 is 779 W.

With an eccentricity of 0.5 R, which could easily occur, the maximum shear stress is about 1053 W and the maximum principal stress f_1 about 1168 W.

If the eccentricity of the load is greater than 0.5 R the stresses are still more in excess of the nominal safe load for axial loading. It is very important, therefore, that the ends of springs should be so designed as to insure axial loading. This is moderately simple for tension springs, but compres-

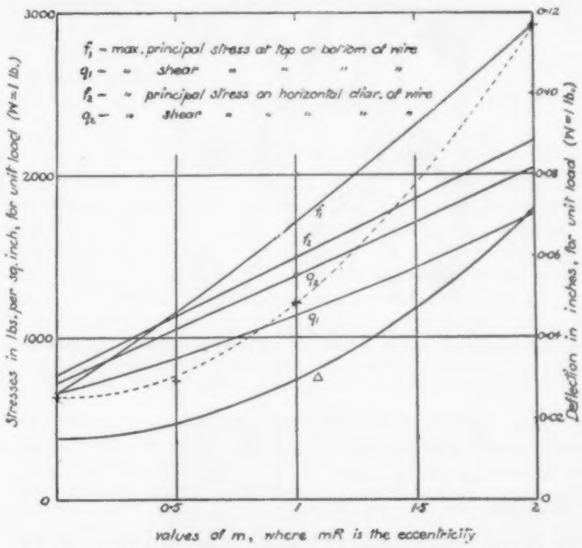


FIG. 2. GRAPHS OF STRESSES IN THE WIRE OF HELICAL SPRINGS CALCULATED BY VARIOUS FORMULAS

sion springs present more difficulty; unfortunately, too, the deformation of a spring under an eccentric compressive load tends to increase the eccentricity, and therefore still further to increase the stresses.

Some experiments were undertaken in order to test the truth of the general formula for deflection obtained in the original article, and they have generally confirmed it.—*Journal of The Institution of Mechanical Engineers*, No. 7, Nov., 1920, pp. 869-889.

WIRE ROPES RESEARCH

Report has been issued by a Committee of the Institution of Mechanical Engineers covering experimental research on wire ropes for use over pulleys.

It does not appear that the committee carried out any special experimental work of its own, but it very carefully collated all the available information and presented it in a clear form.

The conclusions arrived at are that there is no reliable information available as regards the factor of safety when used over pulleys. No sufficient data are available to estab-

lish a general method for the design of ropes, especially as entirely different problems present themselves in various installations. Thus, the outside wear is most important for a rope working on a large pulley, whereas bending fatigue and internal wear do most damage when a small sheave is used.

The calculation of the bending stress for design does not at present appear to be satisfactory. There is a lack of agreement on the factor to be used with the Reuleaux formula. There is no rational formula which covers the actual conditions and it has not yet been shown that the bending stress is the determining factor in the destruction of a rope. It is suggested that an attempt should be made at an analysis which will separate the three destructive effects: namely, outside wear, wear between the wires, and bending fatigue.

Distinction should be drawn between hardness and tensile strength, which are generally regarded as increasing together.

The information concerning the wire diameter indicates a difference of opinion which was not expected. As regards the adjustment of the lays to suit the diameter of the pulley, some writers have asked for it, but there is no exact information which bears on this point. The balance of opinion favors Lang's lay, where it can be used, but the preference is not shown so clearly by American engineers.

The effect of different angles of bending of the cable over

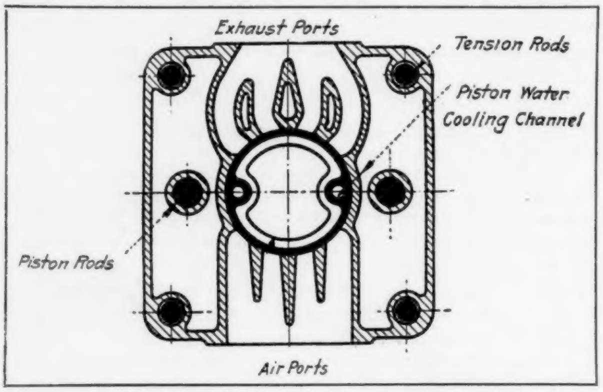


FIG. 3. SECTION THROUGH POWER CYLINDER OF THE MANNING, MAXWELL & MOORE MARINE DIESEL ENGINE

the pulley appears to be explained very clearly by Leffler, although some opinions are at variance with his conclusion. The formula he gives to calculate the true radius of curvature of the rope does not agree with that of the Trenton Iron Company.

The report points out the scarcity of experimental data and gives the impression as if in the field of wire rope for use over pulleys, there is scarcely a single element of design on which sufficient information is available and an agreement exists between engineers. To say the least, this is a very surprising state of things considering the extensive and long use of such wire ropes.—*The Journal of the Institution of Mechanical Engineers*, No. 7, Nov., 1920, pp. 835-868.

GOLDBERG DOUBLE-ACTING TWO-CYCLE MARINE DIESEL ENGINE

DESCRIPTION of an engine in which the scavenging pump is in two stages, the first stage serving for scavenging proper and the second stage for supercharging the working cylinder and also as the first stage for the injection-air compressor. With this arrangement the low-pressure injection cylinder requires not over 70 per cent over its displacement when using air at atmospheric pressure. The air-pump piston closes the scavenging ports ahead of its dead center for a distance, preventing the pump on its return stroke to fill again from the working cylinder.

This means that the scavenging port of the pump cylinder is not uncovered again until the working piston has covered the scavenging ports of the power cylinder.

To provide a better cooling of the pistons, the piston rods are extended into the upper cylinders and are drilled as shown in Fig. 3, one rod serving for water intake and the other for water outlet. The stuffing boxes proper for these sliding pipes (Fig. 4) consist of a light tubing with a collar at the bottom extending to the lower end of the cylinder casting. The packing is held between the lower collar and the gland in the form of a tube.

It is claimed that the double-piston-rod arrangement besides other advantages accomplishes also a great saving in the construction of the connecting rods. With this, the cross head proper consists of a simple steel forging to which the crosshead shoes are fastened in a conventional way, but the forked type of marine rod is not used any more.

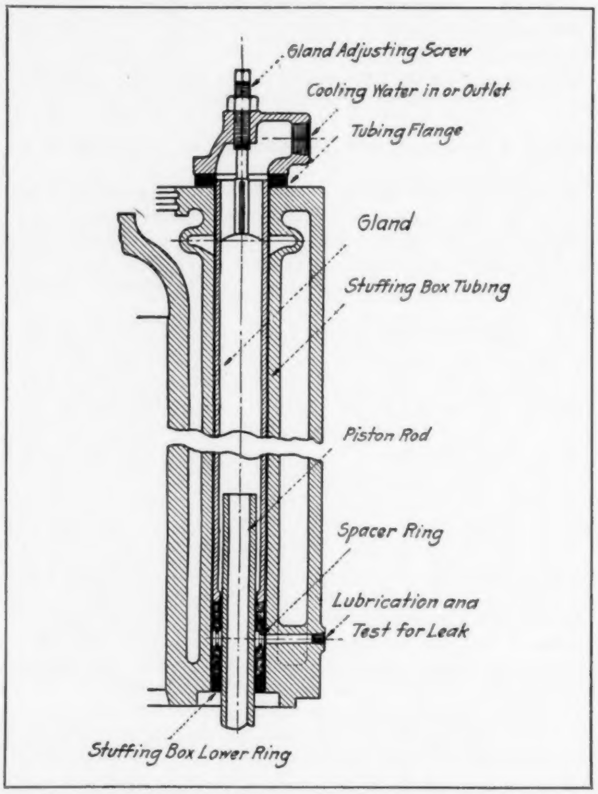


FIG. 4. A LARGE SECTION OF STUFFING BOX FOR PISTON-COOLING ARRANGEMENT, MANNING, MAXWELL & MOORE MARINE DIESEL ENGINE

The four-cylinder 3,000-shaft hp. engine of this type has the following dimensions:

Bore	22 in.
Stroke	33 in.
Speed	120 r.p.m.
Piston speed	660 ft. per min.
Shaft mean effective pressure (m.e.p.)	66 lb. per sq. in.
Overall length, including flywheel, thrust block and air compressor	40 ft.
Overall height from center line of shaft.	26 ft.

A shaft m.e.p. of 66 lb. per sq. in. is a very conservative figure. The low-piston speed of 600 ft. per min. was selected with propeller efficiency in view. A shaft m.e.p. of 66 lb. per sq. in. can be obtained without surcharging the cylinders and the great overload capacity of this type of engine for forced runs of vessels may well be of great value. With surcharging and increasing the speed of this engine, say, to about 160 r.p.m., we can obtain 3,000 shaft hp. for short periods, though it may not be advisable to carry this load through continuous days of service.—*Motorship*, Vol. 5, No. 11, Nov., 1920, pp. 993-994.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

SEALING OF WATER HORIZONS IN OIL WELLS BY MEANS OF CEMENTING PROCESS

By A. A. Downs

There are few oil fields that have no water problem peculiar to themselves, and still fewer without water horizons in the strata to be penetrated in the search for petroleum. Many promising areas have been ruined by careless exploitation without proper care to exclude water encountered from the bore hole, and in most countries special legislation has been enacted to ensure the protection of oil horizons from water encroachment by way of the wells drilled. In established fields, the levels at which water may be expected are known, and the wells are drilled with a view to carrying the water string of pipe to the correct depth, where the operation of cementing is carried out. The plant required for this operation consists of a string of steel tubing long enough to reach to the bottom of the well, and generally 3 inches in diameter, and a high-powered force pump together with the necessary connections. The pumps are generally of the duplex type and constructed to handle heavy muddy fluids efficiently. Most operators prefer to have two pumps on hand, as even a short stoppage may be fatal to the success of the job, and even damage the well. The size of the pump depends on the amount of cement to be used and the depth of the well, and often on the condition of the latter, but generally speaking it should be capable of exerting a pressure of 700 pounds, and putting through 50 barrels of cementing fluid in half an hour.

In Fig. 1 all connections are shown in place and all essential parts are indexed. The first essential in determining whether the well is in right condition for cementing is to have the pipe to be cemented perfectly free in the well, so that it can be lifted and lowered without difficulty. The pipe should be tested several times by lowering it and raising it several feet. All being in order, the tubing is put in and the well head connected to the pump. The pump is started on water, which passes through the tubing to the bottom of the well and up to the surface on the outside of the pipe, to make more certain that the pipe is free and to wash away small obstructions; the pipe is tested while this is going on. The cement is then quickly mixed, the fluid being made quite thin and as easy as possible to handle with the pump. At the time of starting the cement into the well the casing should be about 18 inches from the bottom of the well; the water is cut off and the cement mixture taking its place is forced into the well as fast as possible.

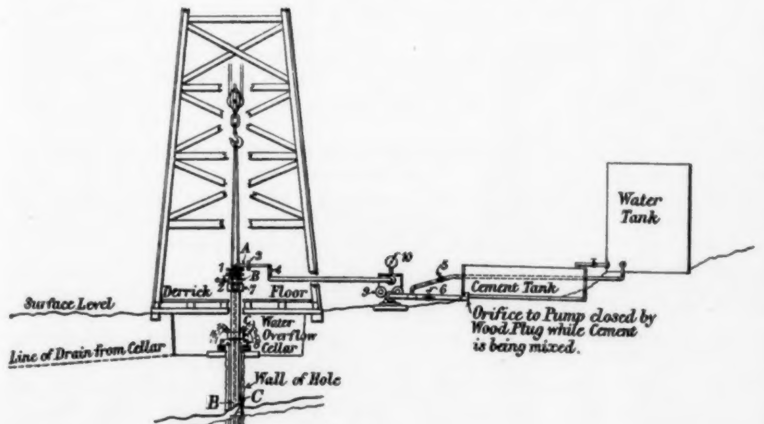
The strata at the bottom of a hypothetical well are represented in Fig. 2, which shows the position of the pipes and tubing and the cement below and behind the pipe, at this stage of the operation.

The well is left for about a month, to allow the cement to set. When drilling is again started, a certain amount of set cement will be found inside the pipe, but this is easily drilled out in the usual manner.—Abstracted from *Engineering*, London, November 5, 1920, pp. 596 to 598.

BY-PRODUCT EXPANSION IN NON-METALLIC MINERAL INDUSTRIES

By Oliver Bowles, Washington, D. C.

It is estimated that the value of the raw materials in the non-metallic minerals exclusive of coal, oil, gas and related minerals, produced in 1919, together with certain of the primary products ordinarily manufactured at the mine, exceeded $800,000,000. In many of the producing industries of this great group, the waste is so great that the expense of handling is an important item in the production cost. The utilization of waste is receiving unusual attention in many of the non-metallic industries at present.



1 Split gland stuffing-box, quickly removable.
2 Relief-valve.
3 Quick disconnecting joint.
4 Swing joint or flexible pipe.
5 Water-gate valve.
6 Cement-gate valve.
A. A. = tubing.
B. B. = pipe to be cemented.
Supported on :—
7 = elevators on slings ready to lower.
C. C. = Next outer pipe to B. B. on :—
8 = Casing clamps.
9 = Pump.
10 = Pressure-gauge.

FIG. 1. WELL HEAD CONNECTIONS USED FOR TUBING METHOD OF CEMENTING

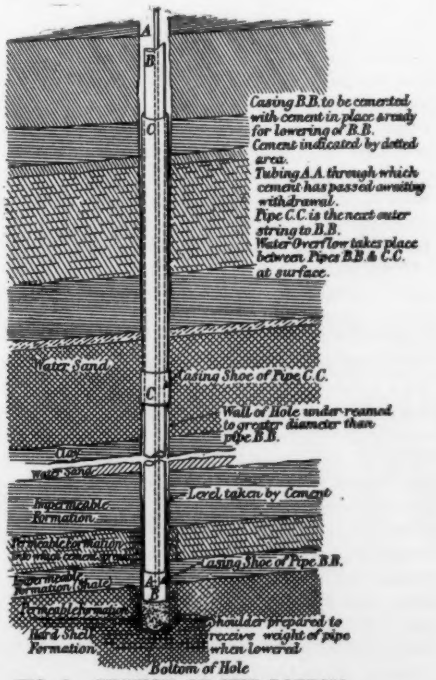


FIG. 2. SECTION OF THE BOTTOM OF A WELL

The recent development of various types of artificial roofing has adversely affected the slate industry. The proportion of waste is high, in some places exceeding 90 per cent of gross production. The North Wales Development Co., Ltd., of Bethesda, Wales, has developed a series of waste slate by-products. The waste is said to have been used satisfactorily for the manufacture of pottery and tiles. Waste slate is also pulverized and used as a filler in abrasive soaps, rubber, asphalt, paint, flooring, etc. The most important by-product is brick, the present production of which is about 10,000 per day.

In the granite industry there is considerable waste, particularly in monumental granite areas where the proportion of waste is almost as high as in slate quarries. As crushed granite is an excellent road material, the enlarged program of highway construction offers a promising outlet.

In the mica industry, waste is utilized in the manufacture of ground mica. There is, however, the possibility of by-product development in the mining process. Mica occurs in pegmatites, which consist chiefly of feldspar and quartz; possibly much of this feldspar could be utilized in the ceramic industries.

Waste marble is used to some extent for rip rap, for terazzo flooring, and for agricultural purposes. The latter use could be greatly extended. Marble waste is also pulverized and sold as marble flour; for certain purposes, this has been successfully substituted for imported whiting. In an attempt to discover profitable uses for small pieces of marble, two companies, independently, have recently experimented with a process of facing concrete blocks with slabs of marble too small for other structural uses; their method gives promise of practical results. A fluorspar company, in Illinois, recovers calcite from the jig tailings and pulverizes it for agricultural limestone.

In the talc industry, waste could be utilized in manufacturing. While nearly all the off-color and impure talc now mined in the United States is wasted, in South Africa and Germany such materials are manufactured into special products, which, with the stimulation of an advertising campaign, have found a ready market.—To be presented at New York Meeting, February 14-17, 1921.

THERMAL EXPANSION OF COPPER AND ITS IMPORTANT INDUSTRIAL ALLOYS

By PETER HIDNERT, Washington, D. C.

DATA on the thermal expansion of 128 samples of copper and its important alloys of various compositions, heat treatments, mechanical treatments, etc., are presented. The specimens contained from 56 to 100 per cent copper and were prepared in a number of ways—cast, cast and cold rolled, extruded, extruded and cold worked, hot rolled and cold worked. Most of the samples were examined from room temperature to about 300° C. (Several specimens were cooled to —50° C. and then heated to + 300° C.)

Practically all available information on the thermal expansion of copper and its alloys is briefly reviewed. A description of the apparatus and the preparation of the samples, etc., is given.

Definite mathematical relations were found to exist between the coefficients of expansion and the copper content of most of the alloys investigated. In general, the coefficient of expansion increases with a decrease in the copper content. The addition of lead or tin has a decided effect on the coefficient; the former element generally decreases, and the latter increases the coefficient.

In the case of alloys containing 62 per cent copper, it was found that the coefficients did not materially differ in cast or cold-rolled specimens, and for alloys containing 90 per cent copper, a similar agreement existed. For alloys with a copper content from about 62 to 90 per cent, the cold-rolled alloys have greater coefficients than the castings, and for alloys containing more than 90 per cent copper, the reverse is true. The coefficients of the inside sections of the castings are generally slightly less than those of the outside sections. A relation exists between the density and thermal expansion of the cold-rolled copper zinc alloys.

The coefficients of the cold-rolled tin alloys are less than those of the castings. Cold rolling and drawing, therefore, cause a diminution in the values of the coefficients.

Owing to the large number of varying elements in the hot-rolled and extruded samples, it was impossible to determine the exact effect of each constituent element. In general, however, the coefficients are greater than the extrapolated values obtained from the quadratic equations of the copper-zinc alloys, showing a tendency toward increasing values as impurities are added.

The differences between the various series of samples are discussed and presented graphically.—To be presented at New York Meeting, February 14-17, 1921. This paper will not be printed in full by the Institute.

POTASH IN NEW JERSEY GREENSANDS

By GEORGE ROGERS MANSFIELD, Washington, D. C.

THE United States Geological Survey, in coöperation with the New Jersey Department of Conservation and Development, in 1918-19 explored the greensand beds of New Jersey as a source of potash. Here potash occurs chiefly in the mineral glauconite, which imparts to the greensand its characteristic color. The only glauconite-bearing formations of commercial importance in New Jersey, which, from present data, are also the richest in the country, are in ascending order the Navesink, Hornerstown, and Manasquan marls of Upper Cretaceous age. The Navesink and Hornerstown are separated from each other toward the northeast by the Red Bank sand and the Hornerstown and Manasquan are separated by the Vincentown sand, important locally as a water-bearer and as a source of lime.

Preliminary examination showed that drilling would be necessary; 19 holes were sunk, ranging in depth from 9 to 70 feet, and averaging 37 feet. A series of continuous samples of material from top to bottom was obtained at most of the holes. The data from borings were supplemented by well and field data on file in the office of the New Jersey Department of Conservation and Development. Five type areas of 2½ acres each were made the basis of specific estimates; these were at Salem and Woodstown, Salem County, Sewell, Gloucester County, Somerdale, Camden County, and Marlton, Burlington County. At Sewell, three greensand beds of commercial quality and thickness have been recognized, which are generally distinguishable throughout the region where borings were made. These are respectively gray or bank marl, green and chocolate marl.

It is conservatively estimated that the New Jersey greensands contain 256,953,000 short tons of potash K_2O that could be mined by open-pit methods. At the rate of importation for the five years preceding the war, including 1914, this quantity could supply the needs of the United States for nearly 1000 years. Should it become practicable to use underground methods of mining, the available quantity of potash would be enormously increased.

Four companies have undertaken to produce potash from New Jersey greensand. Small quantities of potash have been made and sold but no activity on a commercial scale has yet been reported. The first two produce potash in the form of chloride without by-products. The third aims to utilize the entire greensand in fertilizer, having first converted the potash into available form. The fourth produces a caustic potash and a by-product that may be utilized as agricultural lime or in the manufacture of brick or tile. It has under construction a large plant capable of handling 1000 tons of greensand per day at New Brunswick, N. J. In addition, by experiments, a company at Coplay, Pa., using a Cottrell dust-collecting system and greensand in its cement mixture, has demonstrated the feasibility of increasing its output of by-product potash.—To be presented at New York Meeting, February 14-17, 1921.